

DOCUMENT RESUME

ED 260 935

SE 045 975

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TITLE The Influence of the Eighth Grade Science Teacher's Gender, Classroom Laboratory Emphasis, Level of Understanding of Science and Career Interest on Eighth Grade Girls' Science and Engineering Career Interests.
PUB DATE Jun 82
NOTE 229p.; Ph.D. Dissertation, Florida Institute of Technology. For a paper based on this dissertation, see SE 045 974.
PUB TYPE Dissertations/Theses - Doctoral Dissertations (041)
-- Reports - Research/Technical (143)
EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS Engineering; *Females; Grade 8; Junior High Schools; *Role Models; *Science Careers; Science Education; Science Instruction; *Science Interests; Science Teachers; *Secondary School Science; Sex Differences; *Sex Role; Teacher Effectiveness
IDENTIFIERS Science Education Research

ABSTRACT

This study sought to determine: (1) whether eighth-grade science teachers serve as sex role models and therefore enhance eighth-grade students' science and engineering (SE) career interests; and (2) if the SE career interests of eighth-grade girls are related to the sex and selected teacher effectiveness characteristics of their eighth-grade science teachers. Subjects were 30 eighth-grade science teachers (14 men and 16 women) and 1,937 eighth-grade students (945 boys and 922 girls) in Brevard County, Florida. All students were given an author-developed career interest survey at the beginning and near the end of the eighth-grade school year. Two major conclusions were reached based on analyses designed to test interaction of teacher and student sex on student SE career interest. The first conclusion is that as sex role models, the eighth-grade science teachers were not found to enhance the SE career interests of their students. The second conclusion is that eighth-grade girls' SE career interests were not influenced by the teacher's sex or effectiveness as measured by such variables as observed classroom laboratory emphasis, understanding of science, and career interest. The appendices include the CIS and related materials as well as an observer's teacher evaluation form. (JN)

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THE INFLUENCE OF THE EIGHTH GRADE SCIENCE TEACHER'S
GENDER, CLASSROOM LABORATORY EMPHASIS,
LEVEL OF UNDERSTANDING OF SCIENCE AND CAREER INTEREST
ON EIGHTH GRADE GIRLS'
SCIENCE AND ENGINEERING CAREER INTERESTS

by

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Submitted to the Graduate Faculty
in Partial Fulfillment of the
Requirements for the degree of

Doctor of Philosophy

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(Publication No. . . .)

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The two major objectives of this study were: (a) to determine whether eighth grade science teachers serve as sex-role models and therefore enhance eighth grade students' Science and Engineering (S/E) Career Interests, and (b) to determine if the S/E career interests of eighth grade girls are related to the sex and selected teacher effectiveness characteristics of their eighth grade science teacher.

The study involved 13 middle/junior high schools, 30 eighth grade science teachers (14 men; 16 women) and 1937 eighth grade students (945 boys; 992 girls) in Brevard County, Florida.

Student S/E career interests were measured using the Career Interest Survey (CIS) which was developed in this study for use with middle school students. The CIS test-retest reliability over a one week period, was .96

(N=57). Concurrent validity coefficients were calculated in two ways: (a) CIS scores were correlated with the Kuder GIS science subscale ($r=.75$, $N=45$) and (b) CIS scores were correlated with a CIS verification scale ($r=.59$, $N=127$).

The study employed a non-equivalent control group design and involved the use of the CIS postsurvey scores as the dependent variable. The CIS presurvey and postsurvey were administered by the classroom science teachers the first week of September, 1981 and April, 1982, respectively. The teacher effectiveness variables included each teacher's (a) observed classroom laboratory emphasis, (b) understanding of science as measured by the Test On Understanding Science (TOUS), and (c) career interest as measured by the math-science teacher scale from the Strong Campbell Interest Inventory (SCII).

A 2 X 2 ANOVA using multiple linear regression analysis was done to test the interaction of teacher and student sex on student S/E career interests. It was found that the interaction did not account for a significant amount of the variance of student S/E career interests ($p>.05$). A statistically significant correlation was found between the CIS pre- and postsurvey scores for the students ($r=.77$, $p<.05$). Also, a correlation between student sex and the CIS scores was statistically significant ($p<.05$), indicating that the

boys scored higher than the girls on the CIS.

A second analysis was done using multiple linear regression analysis with a hierarchical ordering of the independent variables. This analysis involved only the 992 girl students. The order of the variables, in order of importance to this analysis, were teacher sex, observed classroom laboratory emphasis, understanding of science, and career interest. It was determined that none of the teacher variables involved in this analysis accounted for a statistically significant amount of the variance of the girl's CIS postsurvey scores ($p > .05$). It was also found that male teachers had a significantly greater understanding of science and a greater math-science teacher career interest than did female teachers. Science teachers were observed to involve students in laboratory activities 10% of the time on the average, and slightly less than half of the science teachers had SCII scores that would indicate an interest in being a math-science teacher.

The two major conclusions reached in this study were: (a) as sex-role models, the eighth grade science teachers were not found to enhance the S/E career interests of their students, and (b) that eighth grade girls S/E career interests were not influenced by the teacher's sex or effectiveness as measured by the variables used in this study.

ACKNOWLEDGEMENTS

I wish to express my appreciation to the 13 principals, the 30 science teachers, and the eighth grade students from the 13 Brevard and Indian River County schools for enabling me to carry out this study.

I would like to thank my dissertation committee, especially Dr. Fronk, my major advisor, for his constant support throughout my doctoral program and his invaluable suggestions relating to my study; Dr. Horton for the endless hours he spent reviewing my dissertation and his help with the statistical analysis of the data; Dr Wolf for her suggestions on the interaction analysis and her introducing me to the SCII; and Dr. Rowe for her helpful comments and encouragement.

Additionally, I would like to express my appreciation to George Mayer and Kevin Hester for their invaluable computer assistance. I would also like to thank Mrs. Libby Schmidt, Mr. Dave Murray, and Dr. Jane Chaney of the Brevard County school system for their assistance in various aspects of this research. I would especially like to thank Mr. Dave Cole, a Brevard County teacher, who enabled me to collect the validity and reliability data for the CIS.

I would also like to express my gratitude to Sigma Xi, The Scientific Research Society, for their generous Grant-in-Aid of Research which helped to make this study possible.

I would further like to thank Sharon Wilson, Jeff Priest and my fellow SE graduate students for their support and suggestions which helped me to solve many of the small problems in my research.

Finally, I wish to thank my wife, Sharon, and our sons, Jason and Travis, for their support, patience and love which enabled me to complete my graduate work. Without their constant assistance, my graduate studies would not have been possible.

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CHAPTER I

INTRODUCTION

A problem that has been evident in the United States for many years is the low number of women employed in science and engineering careers. According to the 1977 National Science Foundation study titled "Women and Minorities in Science and Engineering," about 96,000 women were employed as scientists and engineers in 1974. This seems like a sizeable number until it is also stated that these women represented only 6% of the 1.7 million employed scientists and engineers in the United States in 1974. In a more recent study done between 1976 and 1978 by the National Science Foundation, it was shown that the employment rate of female scientists and engineers has increased significantly faster than that of men. Women employed in science and engineering (S/E) increased from the 1974 figure of 6 % to 8.3% in 1976 and then to 9.4% in 1978. This still means that 90.6% of the scientists and engineers in 1978 were men. It should be noted that even if the present growth rates of women in S/E remain the same over the next 20 years, women would still represent only 28% of the total employed in S/E in 1998

(Kornberg, 1980).

Why women are so underrepresented in S/E professions has become a major area of investigation over the past 10 years. The low number of employed women in S/E careers probably involves many factors, such as work values, inadequate elementary and secondary science and mathematics preparation, sex-role stereotyping, insufficient female role models, strong family obligations, parent occupational influence, salary and other economic inequities, outright discrimination, and insufficient career education. Researchers involved in womens' career education have placed their primary emphasis on studying how female role models employed in S/E influence girls through special career programs (Lantz & West, 1977). Unfortunately, these role models are only there for a short time and, except in one study by Weiss, Place, and Conway (1978), their effect has not been shown to be statistically significant.

Two science teacher characteristics that may affect the S/E career interests of secondary school girls are: (a) the teacher's sex, and (b) the effectiveness of instruction. Neither of these science teacher characteristics has been explored thoroughly in the research literature. The first teacher characteristic

that will be discussed in this chapter will involve the teacher as a sex-role model and how this may influence students' S/E career interests. In a later section of this chapter teacher effectiveness will be defined and the influence of this factor on students' S/E career interests will be discussed.

Science Teachers as Sex-Role Models

It has been reported by Weiss (1977, cited in Buccino, 1980) that, in grades 7 - 9, only 30% of the science teachers are women. This is considered a primary time when students are faced with making major decisions in their preparation for the future. Many students have their last encounter with science during grades seven through nine, therefore, the absence of female role models may be an important factor for young girls. The absence of female role models may be even more serious at the high school level. In grades 10-12, since women drop out of college preparatory courses earlier than men and usually take less science (Remick and Miller, 1977). At the high school level, Weiss (1977, cited in Buccino, 1980) has found that only 24% of the science in grades 10-12 is taught by women. Numerous researchers (Button

& Brown, 1980; LaFitte, 1974; Malcom, Hall & Brown, 1976; Tidball, cited in "Women in Science", 1975; Trotter, 1976) have stated that the role of teachers in influencing girls' career interests is very important.

Hardin and Dede (1973) stated that interest inventories show no significant differences between girls and boys in seventh grade in reference to preferences for science, but significant differences do appear after eighth and ninth grades. At this time girls' interests in science decrease.

In a recent study by Wright and Hounshell (1981) of science interests of 150 outstanding high school students involved in the North Carolina Junior Science and Humanities Symposium, it was found that the boys' interest in science was significantly higher than the girls' interest. Seventy-four percent of the students responding stated that their interest in science developed through school related activities. It was also found that school was significantly more influential for female students than for male students. Students rated teachers in grades 10-12 as the most influential factors in developing their interest in science, with junior high teachers, textbooks and field trips rated as second, third, and fourth in their influence, respectively. This

study highlighted the importance of the teachers' role in stimulating students' interest in science, with high school and junior high school teachers rated as the most influential factors.

In another study conducted by Stake and Granger (1978), it was found that when science students and science teachers were of the same sex, there was a greater science career commitment by students than when the sexes were different. These results held true for both boys and girls. They also discovered that the influence of same-sex teacher models was also related to the teacher's attractiveness as viewed by the student. Teacher attractiveness was defined as the rating given by a student to a teacher based on a 7-point scale as to how much they would like to be like their teacher. Students found to have greater science career commitments generally had larger amounts of individual science teacher contact. Stake and Granger concluded in this study that the scarcity of female science teachers in the high schools was a factor that discouraged girls from science career goals. They also suggested that same-sex student-teacher contacts was an important factor in initiating and maintaining science career interests by students.

In a review of twelve National Science Foundation programs funded to study the reasons for the small number of women in S/E careers, Lantz and West (1977) concluded that longer contact periods between female models and female students should be used. They also stated that the effect of school personnel on female career interest should be investigated, since teachers and guidance counselors have the potential for long-term and direct influences.

In a 1976 conference of minority women scientists, there was a general agreement that high school teachers were negative or neutral in their effect on minority women's career choices. The minority women scientists felt that teachers had lower expectations for women, especially minority women. The women at the conference also mentioned that it was important to have a teacher of the same ethnic or racial background to relate to in their schooling. There were no reports of the sex of the teacher being an important factor (Malcom, Hall, & Brown, 1976).

Science Teacher Effectiveness

Introduction to Science Teacher Effectiveness

In a National Science Foundation report on science education involving a number of case studies, Stake and Easley (1978) are quoted as stating that:

What science education will be for any one child for any one year is most dependent on what the teacher believes, knows, and does--and doesn't believe, doesn't know, and doesn't do. For essentially all of the science learned in school, the teacher is the enabler, the inspiration, and the constraint. (p.19:1)

Stake and Easley concluded that most of the science for most of the students is learned in school. They also concluded from their study that science learning will occur only if the teacher can continue to remain motivated enough, despite the obstacles, to teach both the knowledge and the inquiry process of science.

Since several researchers feel that the classroom teacher plays the pivotal role in the nature of the learning experience in the science classroom, it is

important then to consider the effectiveness of the teacher (Balzer, 1970; Rutherford, 1979; Shulman & Tamir, 1973).

McNeil and Popham (1973) have stated that "a teacher is a person engaged in interactive behavior with one or more students for the purpose of effecting a change in those students" (p. 219). They also stated that "the test of a teacher's effectiveness is his accomplishment of the goals of education as displayed in the pupil's behavior following instruction" (p. 220).

In my study, I investigated the relationship between girls' S/E career interests and the following three measures of teacher effectiveness: (a) the percent of time students spend in the science teacher's class involved in laboratory activities (classroom laboratory emphasis), (b) the science teacher's level of understanding of science, and (c) the science teacher's career interest. Each of these teacher effectiveness variables will be discussed separately in the following paragraphs.

The Science Teacher's Classroom Laboratory Emphasis

Blosser (1981) has stated that, in her opinion:

A knowledge of how a scientist goes about his/her work appears to be an objective closely related to that of science literacy. Experiencing the methods scientists use, via laboratory activities, may lead to a more scientifically literate citizen. It may also lead to continued interest in science as a career. (p. 36)

Several science educators agree that there are specific outcomes of laboratory work from which a student may benefit. Shulman and Tamir (1973) have grouped objectives of laboratory work into five major categories. One of these objectives is attitude. Included in this category of attitude is interest and liking science. They suggest that a student who likes science and is interested in science may also consider science as a future career. Pella (1961), in reviewing the objectives of teaching science in 22 states, found that one of the most commonly held objectives of the science laboratory is stimulating interest in science. Only one study to date has looked at the relationship between science career interests and laboratory work.

Pella and Sherman (1969) compared two methods of utilizing laboratory activities in teaching IPS. Using the Kuder General Interest Survey Form E to measure

science career interest, they found no difference between the group that did labs (experimental group) and the group that didn't do the labs but saw films of the lab activities (control group). Since they didn't use random assignment for the groups and had only a small sample ($N=50$), their power to detect differences between the group means was less than 50%. Therefore, their results are questionable. This study indicates that there is a need to look at the relationship of student career interests and the percent of time they have spent doing laboratory activities in science class.

In my study, a modified version of Good and Brophy's (1978) Variety of Teaching Methods Evaluation Form will be used to record for each teacher the percentage of time students are involved in laboratory activities. Each teacher involved in this study was observed for at least 4-5 hours of class instruction time. A more detailed description of the evaluation form is given in Chapter III.

The Science Teacher's Understanding of Science

It is the opinion of Lawson and Renner (1975) that the classroom teacher generally uses his/her own

understanding of the structure of the academic discipline to select the concepts of importance to be learned. The teacher's goal is to provide the learner with his/her own understanding of the nature and structure of the discipline.

In an attempt to establish a method of evaluating teacher competence and effectiveness, the National Association of Biology Teachers has developed certain criteria to judge the "Outstanding Biology Teacher". In a study by Dieter and Hounshell (1975), it was found that two of the significant criteria for evaluating teacher effectiveness for the "Outstanding Biology Teacher" were: (a) the concern for student understanding of the scientific process and (b) the student's understanding of the essential concepts of the discipline.

Kimball (1967-1968) stated that, developing an understanding and appreciation of science and scientists is one of the most commonly stated objectives for science education. Saunders (1955) has stated that the understanding of science and scientists is the "most important" purpose of science teaching.

In my study, the teacher's level of understanding of the nature of science will be measured using the Test on Understanding Science (TOUS) developed by Cooley and

Klopfer (1961). Understanding of science as defined by Cooley and Klopfer includes three major areas and several themes. The three major areas are: (a) Understanding the scientific enterprise, (b) Understanding scientists, and (c) Understanding the methods and aims of science (Cooley and Klopfer, 1961).

It has been concluded by several researchers that the teacher's understanding of science has been shown to have a significant effect upon the outcomes of science instruction. Some of the outcomes that are affected by teachers' understanding of science are their students' understanding of science, student attitude toward science and student interest in science (Olstad, 1969; Yager, 1966; Zingaro & Colette, 1967-68).

The TOUS was chosen as the instrument to measure the teacher's understanding of science because it was specifically developed as a research tool for studies similar to my research. Further information about the TOUS is included in Chapter III.

The Science Teacher's Career Interest

Most preservice secondary school science teachers do not view themselves eventually as a middle school science

teacher, but they do view themselves eventually as a biology, chemistry or physics teacher (Mechling, 1975).

Beizenherz (cited in Ochs, 1981) has stated that the "reality in many districts...dictates that new teachers often accept middle school positions because of vacancies at that level" (p. 224).

Beizenherz has also stated the following about middle school science teachers:

These teachers are often frustrated high school or elementary school teachers who, because of seniority policies, must wait their turn to move to their desired level. In too many cases teachers certified in mathematics, physical education, music, etc., are placed in middle school science positions, depending on the needs of the district at that point in time. (pp. 224-225)

Beizenherz finally concluded that middle school science teachers in many cases lack a real interest, commitment and enthusiasm for science teaching and he suggests that one of the reasons for this lack of commitment, enthusiasm and interest is that these teachers did not receive job placement that really matched their perceived interest and capabilities.

In two National Education Association (NEA) nationwide polls, teachers were asked if they would still go into teaching if they had the choice to make over again. In the first of these polls taken in 1966, only 9% of the teachers stated that they would not have gone into teaching again. In comparison, 13 years later in a second poll taken of teachers in 1979, it was reported that 32% of the teachers polled said they would not have gone into teaching if they had to make the choice over again. It may be concluded from the two polls that almost one third of the people involved in teaching today would rather be doing something else. It is further suggested that this decline of interest in teaching by those already in the profession seems to be growing each year (National Public Radio Education Services, 1980).

How this lack of interest by teachers already employed in schools affects a teacher's effectiveness in the classroom is unclear at the present time. In reviews dealing with teaching effectiveness, several researchers have concluded that teacher interest in teaching is an important factor in inspiring student interest in learning (Brophy & Good, 1974; Bybee, 1973; Dieter & Hounshell, 1975; Stedman & Breen, 1977).

In light of the above comments by the various

researchers, there is a definite need to look at the relationship of student S/E career interests and the career interests of their science teacher.

In my study, I have used the Strong Campbell Interest Inventory "SCII" (Strong & Campbell, 1974) to measure the teachers' level of career interest. The specific occupational scale of the SCII that was investigated is the teacher's level of career interest in being a math-science teacher. This instrument was chosen because it was highly recommended as a valid and reliable instrument for measuring adult career interest, by a practicing psychologist on my dissertation committee (Wolf, Note 5). A more detailed description of the instrument is given in Chapter III.

Student Science and Engineering Career Interest

Student career interest in science and engineering is usually measured as one aspect of a standardized test in which career interests in general are measured. Some of the most popular career interest tests for the secondary school level include the Kuder General Interest Survey, Form E (Kuder, 1976), Planning Career Goals Interest Inventory (American Institutes for Research,

1975), JOB-O (Cutler, Ferry, Kauk & Robinett, 1980a), and The Self Directed Search, Form E (Holland, 1979). Many of these tests give separate scores for natural and physical sciences, or outdoor and indoor science, or engineering and science, or they do not include the teaching of science in with science careers. Because of this separation of the different areas, the overall interest in science and engineering for a student cannot be determined. These problems in getting one score measuring general science and engineering career interest led me to develop my own Career Interest Survey (CIS) to use in this study. In the CIS, a science or engineering career is characterized by the completion of at least a four year college program with a major in science, science education or engineering. The CIS S/E interest score includes a measure of interest in all occupations of science and engineering, such as the medical related fields, behavioral sciences, biological and physical sciences, architecture, middle, junior high, senior high and college level science teaching, and any other related fields. A more detailed description of this instrument is give in Chapter III. Also, a copy of the CIS, an answer key, and an instruction manual for the instrument are given in Appendices B, C, and D.

Rationale for the Study

There are a number of reasons for studying the influence of the sex and teaching effectiveness of science teachers on womens' career choices. First, schools that have a high percentage of male science and mathematics teachers at the middle and secondary levels could incorporate more career education programs in science and engineering especially for girls, to make up for the absence of female role models. Second, any negative influences to women entering S/E careers, such as teacher sex bias, could possibly be reduced by a change in curriculum or by a possible improvement in the effectiveness of instruction by science teachers. This of course assumes that by increasing teacher effectiveness sex-bias is reduced. Third, since science teachers are in contact with students for a longer period of time than can be developed in outside funded programs, more emphasis might be placed on science teacher career influences. Fourth, if sex-role models and science teacher effectiveness are found to be important in career interests and choices, this might influence school administrators to consider these factors in determining

science teacher assignments and evaluation practices, thereby modifying the composition of their faculty and the effectiveness of science teaching.

Statement of Purpose

The purpose of this investigation was to determine the role that eighth grade science teachers' sex and teaching effectiveness have on eighth grade students' career interests in science and engineering. Teacher effectiveness is defined by (a) the percent of laboratory activity time their students spend in the classroom (classroom laboratory emphasis), (b) the science teacher's level of understanding of science, and (c) the science teacher's level of career interest in being a math-science teacher.

Hypotheses

Research Hypothesis

There will be a statistically significant positive correlation between the CIS postsurvey scores of eighth grade girls and their eighth grade science teacher's

gender, classroom laboratory emphasis, level of understanding of science, and career interest.

Null Hypotheses

The null hypotheses listed below were tested in this study. The rationale behind the stated null hypotheses and the statistical methods used are discussed in Chapter III.

1. No variance in the CIS postsurvey scores of eighth grade students will be accounted for by the interaction of the gender of the eighth grade students and the gender of their eighth grade science teacher.

2. No variance in the CIS postsurvey scores of eighth grade girls will be accounted for by the gender of their eighth grade science teacher.

3. No additional variance in the CIS postsurvey scores of eighth grade girls will be accounted for when the percent of laboratory activity time spent in the classroom is added to the gender of their eighth grade science teacher.

4. No additional variance in the CIS postsurvey scores of eighth grade girls will be accounted for when their eighth grade science teacher's TOUS score is added

to the gender of their eighth grade science teacher and the percent of laboratory activity time spent in the classroom.

5. No additional variance in the CIS postsurvey scores of eighth grade girls will be accounted for when the SCII score of their eighth grade science teacher is added to the gender of their eighth grade science teacher, the percent of laboratory activity time spent in the classroom, and their eighth grade science teacher's score on the TOUS.

Limitations

The limitations of this study were:

1. This study involved only 13 public and private junior and middle schools in Brevard and Indian River Counties that volunteered to participate in the study. There were three public middle/junior high schools in Brevard that did not wish to participate. Since some of the schools in these two counties were not involved in the study, their absence could have affected the results in that the sample might not be truly representative.

2. This study, involved only two counties in Florida. These counties were found in a coastal area,

and may not be applicable to other areas of Florida or to states other than Florida.

3. The study investigated the impact of the sex of the teacher and the effectiveness of the teacher over a period of only eight months. A longer period of time might have yielded different results, since career interests are considered to be molded over a longer period of time.

4. This was a quasi-experimental study, since the sample was not randomly selected.

5. Students' career interests in science and engineering measured may change drastically during the high school and post high school years. Ideally, the study should have been carried out over a longer period of time to measure the long-term influence.

6. During the school year, each teacher was observed for the percentage of time their students were involved in laboratory activities. The observation time was for 4-5 hours which was only a small portion of the total instruction time during the school year. Therefore this may not have been representative of the laboratory activity emphasis during the entire school year.

7. Originally the study involved 3035 eighth grade students. In reviewing the data, it was discovered that

there were many students that had not taken the either the CIS pre- or postsurvey. It was not anticipated that so many students, approximately 1/3, would move to different classes and schools. Therefore, the sample had to be redefined to include only those students that had taken the pre- and postsurvey with the same teacher. Since the sample was reduced to 1937 students, this may have affected the results by reducing the number of students for each teacher. It should be noted here that some teachers had a greater change in the number of students from the pre- to postsurvey than others. The significance of this fact is unclear.

CHAPTER II

REVIEW OF RELATED LITERATURE

In a 1980 report of the National Science Foundation it was stated that, during 1978, only 9.4% of all of the scientists and engineers in the United States were women. This report also pointed out that the number of women in S/E careers is gradually increasing. However, it was also stated that, even if this increase was to continue at the same rate over the next 20 years, women would still represent only 28% of the employed scientists and engineers in 1998 (Kornberg, 1980).

Why is it that women make up only an extremely small portion of the scientists and engineers in the United States? At a time when our country needs all of the scientific minds we can develop to answer many of our pressing problems, the statistics above seem surprising. What are the reasons behind this imbalance in the scientific work force? What is the current state of research in this area? Can science teachers at all levels do anything to change this trend?

This chapter is divided into two major sections:

(a) Women in Science and Engineering, and (b) The Factors that Influence Student Science and Engineering Career Interests.

Women in Science and Engineering

Employment of Women in Science and Engineering

In a National Science Foundation (NSF) study ("Women and Minorities", 1977) dealing with S/E employment of women, a large number of conclusions were reached. Some of the major conclusions are given below:

1. Women represented only 6% of the total number of employed scientists and engineers in the U.S.

2. Almost one-half of all women scientists and engineers were unemployed (47%) while only 12% of men were.

3. Women constituted 8.7% of the total doctoral scientists, but comprised 7.6% of the employed doctoral scientists and engineers in 1973. Vetter (1975), at the Scientific Manpower Division in Washington, D.C. stated that of 207,500 science and engineering Ph.D.'s in the U.S. labor force, 93.4% were white and 7.9% were women. The value is slightly higher than in the earlier 1977

study, possibly indicating a slight increase in employed women Ph.D.'s.

4. The median annual salary for men in science and engineering in 1974 was \$19,400, while for women it was \$15,700.

5. Among doctoral level scientists and engineers, womens' salaries were 17% less than mens'.

6. Using national averages, the starting salary gap between women scientists and engineers and men scientists and engineers is narrowing. For example, in 1976 the average offer for the men in biological sciences with a bachelor's degree was \$9,840 per year while for women the amount was \$9,540 per year. This can be compared to 1973, in which men in the biological sciences were starting at approximately \$9,012 per year while women were starting with \$7,968 per year. This trend has been reported in other S/E fields.

7. The number of degrees in science and engineering granted to women is gradually increasing.

8. Only 18% of the women (as compared to 50% of men) who earned a B.S. in science and engineering in 1965 and who expressed a desire for a science career were engaged in their chosen career 6 years later.

9. Women employed in scientific professions at

present are predominantly Social Scientists (13.5%), Life Scientists (18.8%), Psychologists (15.6%), Computer Scientists (21.9%) and Physical Scientists (14.7%); while the smallest number of women are employed as Environmental Scientists (1.9%), Engineers (5.2%), and Mathematical Scientists (7.3%).

10. Twenty-five percent of all men and 8% of all women employed in S/E careers are employed at the management and administrative level. At the college level, 15% of all women and 7% of all men who are scientists and engineers are employed as teachers.

11. In 1968, almost 60% of the women in science were employed in education, while in 1974 this value decreased to 25%. Involvement in business, government, and other areas has increased for women.

In a study by Vetter (1977), it was found that more men than women were employed in research and development in 1977. Also proportionally more women scientists and engineers than men were employed full-time in universities. Only 10.4% of scientists and engineers in research in 1974 were women. Of all scientists and engineers in 1974, proportionally more than 2 times as many women were in applied research as men. It was also shown that women Ph.D scientists and women engineers were

more likely to work in academic institutions and less likely to work in industry and business than men. More women were research assistants than were professors and more women were employed at two-year colleges (20.4%) than at four-year universities (14.9%). Even in the federal government, women with Ph.D.'s are only a small percent (4.7%) of the scientists and engineers employed. The women that are employed by the federal government generally hold a lower ranking position despite being on an equal academic level (Vetter, 1977).

In another NSF study during the period of 1976-1978, Kornberg (1980) reported that the number of women scientists and engineers has increased faster than men (17.4% versus 2.8 %). Because of this noticeable increase of women in S/E careers, women now constitute 9.4% of all scientists and engineers in the U.S. The report points out, though, that even if the increased participation of women in S/E careers were to continue for the next 20 years, women would still make up only 26% of the scientist and engineers by 1998.

The greatest increase in employed women in S/E careers was in the area of engineering. This increase is attributed to the high market demand for women engineers and the increasing number of women earning S/E degrees

(Kornberg, 1980). Kornberg reported that women's unemployment rate in S/E careers remains approximately two times that of men (2.4% women to 1.0% men). He also reported that salary differentials between men and women in S/E are narrowing, particularly for younger women. For example, women under 30 years of age with doctorates have average salaries only 7% less than men. Overall for all age groups, women in S/E careers still earn 20% less than men in S/E careers.

Career Barriers for Women in Science and Engineering

In reference to why women do not pursue S/E careers Zuckerman and Cole (1975) have suggested the following:

Women encounter three barriers to becoming productive scientists. First, science is culturally defined as an inappropriate career for women; the number of women recruited to science is thereby reduced below the level which we would obtain were this definition not prevalent. Second, those women who have surmounted the first barrier and have become scientists, continue to be hampered by the belief that women are less competent than men....And third,...there is some

evidence for actual discrimination against women in the scientific community. To the extent that women suffer from these disadvantages, they are victims of one or more components of the triple penalty. (p. B4)

Historically, it was believed that educating women was a waste of resources as far as preparation for employment was concerned. Centra (cited in "Women in Science", 1975), of the Educational Testing Service, studied a sample of women who received doctorates in 1950, 1960, and 1968 and found that 80% of these women were employed full-time after receiving their doctorates compared to 95% for men. He stated that this indicated that a high percent of women receiving Ph.D.'s do in fact work full-time.

Studies have shown that women who have been successful in science come from a small, narrow slice of society. The general characteristics of the women scientists are that they are white and from a middle or upper middle class family in which both parents were educated and able to help with finances. The families were small, supportive, and the father's role was important. Generally, the father encouraged his daughter's development ("Women in Science", 1975).

The major barriers that have been reported in the literature which may prevent women from entering into science and engineering fields are:

1. Sex Roles/Stereotyping in Society. Gettys and Cann (1981), in a study of children ranging from 2 1/2 to 8 years old, found that occupational sex-stereotypes appear as early as 2 1/2 to 3 years old in children. Their study involved 155 children; in which each child was interviewed individually by a trained interviewer. They concluded that the child 2 1/2 - 3 years old is exposed to a sufficient variety of occupations to be able to label reliably the generally accepted male and female occupations. These results generally agree with earlier reports of the research in this area (Looft, 1971; Maccoby & Jacklin, 1973; Ward, 1969).

Uustot (1980), in a study of 14 third-grade, 10 fifth-grade and 17 seventh-grade girls, reported that sex-role occupational attitudes were more liberal with increasing grade level, with grade seven girls being the most liberal. It was also found that a girl's choice of her own potential occupation may not be directly related to responses on sex-role occupational attitudes. Uustot implied that the occupation that a girl intends to pursue may be governed by sex-roles while general career

attitudes are not. The author reported that, because of the small sample size, further research may be needed to verify the findings.

Martina Horner, president of Radcliffe, has stated that women are a victim of the "double bind" in testing and achievement settings. "The bright woman worries about failure but also about success. If she fails, she is not living up to her own standards of performance; if she succeeds, she is not living up to societal expectations about the female role." (cited in "Women in Science, 1975, p. 10). Many women give up science, especially during the first and second years of college, because of this pressure. It has been suggested by Trotter (1976) that psychological predispositions of women have restricted their participation in science and engineering. Women have a greater inclination to pursue socially oriented occupations while men pursue investigative or analytical work. This is generally due to societal pressure and norms which parents and teachers encourage for sex-appropriate behavior in girls and boys. This area will be discussed in further detail later in this chapter.

Heins and Martindale (1977) studied nearly 100 men and women physicians using a 207 item questionnaire.

They found that role conflicts and an excessive patient to doctor ratio were distinct problems of women physicians. They described the model woman physician in this study as 46 years old, Caucasian, Protestant, upper middle class, married (most likely to a physician), with 2.5 children, from an urban area, from a stable home, living with both parents when growing up, generally an only child or the eldest child, and 80% had mothers who had a positive attitude about their daughters' careers. It was reported that these women were able to carry out successful dual roles as full-time physician and mother.

2. Elementary and Junior High School Science Preparation. Using a sample of approximately 800 elementary school teachers, Weiss (1977, cited in Buccino, 1980) reported that only 23 minutes of the school day is spent dealing with science in kindergarten through sixth grade. This amount of time spent is much lower than on any of the other academic subjects. Seventy-three percent of the science teaching at this level is done by women teachers. At a time when positive models for women in science could be created there is little emphasis on science teaching. In grades seven through nine, there is a large decrease in women science teachers. Since almost all students are required to take

science in grades seven through nine, this is when the majority of students receive their maximum exposure to science and it is also the time at which major decisions are being made for preparation for the future. It is unfortunate that during this critical period there are so few women in science teaching, while only a few grades earlier almost three-fourths of the science teachers are women, yet very little emphasis on science occurs. This topic of secondary science teachers as sex-role models for science careers will be discussed in depth in a later section of this chapter.

3. High School Science Preparation. Remick and Miller (1977) have found that women generally tend to drop out of college preparatory science courses earlier than men and usually take less science than men. Weiss (1977, cited in Buccino, 1980) reported that only 24% of the science in grades ten through twelve is taught by women. This value has possible significance since Button and Brown (1980) have pointed out the potential importance of women science teachers for young girls to emulate at the high school level. This will be discussed in greater detail later in this chapter.

4. Curriculum and Curriculum Aids in the Schools. Hardin and Dede (1973) have asked the question: "How many

women scientists are shown in the textbooks you are using?" (p. 19). They have expressed the idea that sexism in textbooks, especially in the sciences, is one of the factors that influence children's views on potential careers. Cohen and Cohen (1980) and Weitzman and Rizzo (1980) have stated, after reviewing a variety of math textbooks, that the illustrations depict men $2/3$ to $3/4$ of the time. They do report that publishers are now aware of the potential negative effects of stereotyping and have started to change their books in this respect. Recently, after looking over the 4th edition of the BSCS text Biological Sciences: A Molecular Approach (McCarthy, 1980), Richmond (Note 4) stated that slightly more than $2/3$ of the occupational illustrations in this science textbook were women. It would seem that the tide has turned in the other direction.

5. Mathematics Preparation. Many college freshmen women find themselves lacking the prerequisite math for a science major ("Women in Science", 1975). This topic will be discussed in detail later in this chapter.

6. Coed Versus Non-coed Schools. In a study involving sex-role stereotyping in schools, Vockell and Lobonc (1981) reported that having girls develop unfavorable attitudes toward the physical sciences may be

an unintended effect of coeducation. Their study included 476 girls from non-coed schools, 280 girls from coed schools, and 329 boys from coed schools. Students were administered a questionnaire containing a listing of 45 career fields related to academic subjects. The students were asked to rate each career field as to its degree of masculinity or femininity. It was found that the overall physical science score was significantly ($p < .001$) more masculine than the biological science score for all groups. Physical science was reported significantly ($p = .02$) more masculine for coed girls than for non-coed girls.

Vockell and Lobonc (1981) concluded that these results lend support to the hypothesis that the interaction of boys in science classes may cause girls to perceive physical science as more masculine. In reviewing the undergraduate background of 1,500 randomly selected "career-successful" women listed in Who's Who of American Women, Tidball (1973) reported that as the percentage of men students enrolled in a college with women increased, the number of "career successful" women decreased. A "career successful" woman was defined by Tidball as one whose achievements were recognized by being listed in Who's Who of American Women. Tidball reported a

correlation of $-.937$ ($p < .005$) between number of men students in a school and the number of women achievers.

7. Admissions. Centra's study, "Women, Men and the Doctorate" (cited in "Women in Science", 1973), has shown that many universities separate women applicants from men applicants and base acceptances on the proportion of each sex applying. Centra has concluded that since women generally had better records than the men, more women would be accepted if the admissions were based solely on academic record.

Zuckerman and Cole (1973) have stated that it is widely believed by faculty members that women more than men are poor risks as graduate students since they are generally less likely to complete their postgraduate degrees. It was reported that differences in rates of attrition between men and women post graduates is greatest in the sciences. Zuckerman and Cole have explained that this is true but this may be attributed to the negative attitudes of teachers toward women in science.

8. Women University Faculty. Tidball (cited in "Women in Science", 1973) noted that the number of women faculty in all undergraduate institutions has been declining for the past 40 years, while the number of

women students has increased. Without role models, female talent may be lost.

In studying undergraduate background of 1,300 randomly selected "career-successful" women from three editions of Who's Who of American Women, Tidball (1973) found that correlations between "career successful" women and the number of men faculty teaching at the college they attended was not statistically significant. She also found that the correlation between "career successful" women and the number of women faculty teaching at the college they attended was $+ .953$ ($p < .005$). Tidball concluded that the number of young women found to be successful in their careers was influenced by the number of same-sex role models to whom they had access, while in college.

9. Work Values. Work values have an important impact on the areas of employment an individual might pursue. Jerdee and Rosen (1976) found in a survey of 150 women holding nonacademic positions at the University of North Carolina that the two major reasons given for pursuing a higher level career by women were personal achievement and higher income.

LaFitte (1974) studied the career choices of 148 male and female college students at the University of

Texas who were not Anglo-American. Minority women generally stressed altruistic and supervisory relationships in which helping people was most important. Males stressed independence, economic returns, intellectual stimulation, and power. Overall, it was concluded that the most important factor in career choices for these minority students was their own self-concept. Zapolean, (cited in LaFitte, 1974) in a 1961 study, reported that women tend to be motivated more by the fear of potential social rejection than by the benefits of leadership. They are more concerned with getting along than with getting ahead.

LaFitte (1974) and Morris (1978) are in general agreement that work values and career decision making by men and women are generally alike. There are minor differences. Men generally rate school and work experiences as the most important factors in career decision making, followed by family and peers, while teachers are usually rated least in career influences. Women rate school experiences first, followed by friends and family, work experiences, and teachers as being most important in career decisions (LaFitte, 1974).

Morris (1978) studied the career interests of 433 randomly selected male and female college students who

were involved in a career inventory interest program using the computer based system of Interactive Guidance and Information. She concluded from her study that men generally rank security, income, and work in a major field of interest as the highest values while women ranked work in a major field of interest, security, and helping others as most important. Morris found that in the values domain maleness was associated with leadership and high income while femaleness was associated with helping others. Still, in light of these differences Morris concluded that the similarities between the two sexes outweigh the differences. She was careful to point out that because this study was done with college students, it did not truly represent the entire population of the U.S.

10. Salaries. Aufenkamp and Meshkov (cited in "Women in Science", 1975) found that salaries for new women doctorates are generally at a par with men, but the longer the woman has been in the system, the larger the salary gap, possibly because she may not have been able to meet the conventional criteria for salary increases, such as years of service, research, and publications. They attributed time away for family rearing as interfering with the conventional criteria for salary

promotion.

Zuckerman and Cole (1975) pointed out that women scientists are less productive than men in one standard, that is in the publication of scientific papers. Women scientists publish less than men. Interpretations of why this is true have included such things as: women are more often affiliated with academic institutions that do not expect research or publications and women have responsibilities of marriage and motherhood. Zuckerman and Cole reported that neither of these reasons is accurate. It is generally thought that interest in research by women is less than men and this influences publication rates. They suggest that this is an area in need of further research.

11. Family. In a survey of 150 women at the University of North Carolina, Jerdee and Rosen (1976) reported that these women felt that family and life style considerations were the major barriers to career advancement. Jerdee and Rosen suggested that in order for a woman scientist who is married and has children to be successful, she must have a supportive and accomodating husband, must be able to make child care arrangements and must be allowed to have a more flexible work schedule until family responsibilities diminish.

12. Family and Full-Time Employment. Trotter (1976) pointed out that one deterrent to women in science and engineering is the emphasis made on full-time uninterrupted involvement in these fields. A 1975 study done at Georgia Institute of Technology (cited in "Women in Science", 1975) surveyed more than 1,000 women scientists to study the relationships between a professional role and child-rearing. Contrary to popular belief, it was found that marital status had no negative effect on the likelihood of a woman having a full-time career. Eighty-nine percent of the married women with no children at home were working full-time, compared to 86% of the single women and 83% of the child-free formerly married. Similar figures have also been reported by Zuckerman and Cole (1975).

13. Husband's Employment. The husband's job may be another deterrent because if he must shift locations because of a change in employment, the woman will also. If she is a highly specialized scientist, she might not find a job in a new location (Jerdee & Rosen, 1976).

14. Professional Characteristics. Trotter (1976) has pointed out that it is generally believed that men scientists seek out other men as proteges and this may lead to discriminatory practices.

15. Job Commitment. Women generally feel that their lack of commitment in career advancement is due to discriminatory practices of employers, which prevent them from achieving equal pay and status in their chosen career (Jerdee & Rosen, 1976; Zuckerman & Cole, 1975).

Minority Women: A Special Case?

At a conference of minority women scientists, Malcom, Hall and Brown (1976) reported minority women as being in a "double bind". In addition to being women, they are also a minority. Therefore, they suffer double discrimination. Some general conclusions reached by the minority women based on their personal experiences about the status of women in science and engineering are:

1. The general characteristics of a successful minority woman in science are that she could read at an early age, had a strong sense of self worth, was always aware of her ethnic status, remembered the encouragement of a particular teacher or friend, was disciplined to study and was always aware of her sex in a positive way.

2. Generally, high school science teachers were negative or neutral in their effects on career choices. The minority women felt that teachers generally had lower

expectations for them than other members of the class.

3. Most women agreed that no accommodations for language differences were made.

4. There was a definite advantage to having a teacher of the same race or ethnic background to relate to. Generally, there were few role models of the same race or ethnic background to emulate.

5. Counseling was poor or nonexistent with more negative advice than positive. Counselors would recommend students go to a college of their own race or ethnic status, even if it didn't have the correct area of interest for the student.

6. Extreme peer pressure and strong family ties caused emphasis on conforming to the racial and sex roles.

7. The information given about financial aid was inadequate at high school, undergraduate, and graduate levels, hindering further advancement.

8. Course work at the undergraduate level was difficult, not because of intellectual inadequacies, but because they did not receive the correct high school preparation, secondary school was not demanding enough academically, and there were no rigorous laboratory sciences available.

9. Professors at both the undergraduate and graduate level were condescending and had low expectations for them. They were treated as if they hadn't met the entrance requirements.

10. Since there are few post-doctoral positions for minority women, they are not encouraged to pursue these positions even when available.

11. In reference to work, even if a man and woman started at the same level, the man usually advanced faster. It was assumed that men had "innate" abilities of management, whereas women needed credentials. Management personnel and administrators consistently gave different interpretations to identical behavior by men and women.

Three additional comments reported by Malcom, Hall and Brown (1976) are:

1. Minority men have advanced faster in the sciences and engineering than have all women in reaching salary parity, equal job opportunities, and equal advancement, while minority women have not.

2. Women scientists are usually invited for a large number of interviews, compared to the actual number of job offers.

3. Minority women in the labor force since 1970 do

not make up 1% of the scientists and engineers currently employed. The percentage of minority women in college and university positions is extremely small, with the majority being in positions outside of the university. The Black and American Indian women that were employed in colleges were involved predominantly in mathematics, the Hispanic women in engineering, and the Asians in chemistry.

Recommendations made by these minority women for improving the number of women in science and engineering were:

1. Use more mass media, especially programs for children, in which minority women in science are used as role models.
2. Hire more minority women as teachers in universities to increase role models.
3. Do not consider science as optional in elementary school and stress lab science.
4. Improve racially unfair standardized testing.
5. Have more career counseling made available, especially reaching parents.
6. Have better information on higher education and financial aid.
7. Have better counseling in high school and college

courses by advisors.

8. Have more emphasis on bilingual education in schools.

9. Offer more workshops and internships by scientific societies.

10. Emphasize good communication skills in elementary schools and high schools.

11. Urge women to strive for equal opportunity, salary parity, and equal advancement for equal service and qualifications in all careers.

Mathematics: An Important Factor?

Sells and Ernest (cited in Remick & Miller, 1977) have indicated that women are likely to drop out of mathematics courses at the high school level, making it unlikely that they will be able to pursue study of the sciences in college. It has been found by Remick and Miller (1977) that all women take less college preparatory courses in math and science in high school than do Caucasian men. In analyzing high school records of 507 freshmen entering the University of Washington in the fall of 1976, it was found that women dropped out of college prep math sequences earlier than men. On the

average, 60% of men took sufficient high school math to enter college calculus, while only 14 - 37% of other groups were so prepared. Grades were not the factor because the average grade point average of students quitting at a given level of math was higher for women than for men. It was found that all women were more likely to take general or remedial math.

Wise (1978) has shown that math skills are highly correlated with math related careers such as engineering. She has stated that math skills developed during high school are both an essential component of subsequent educational attainment and a significant predictor of success in establishing math-related careers. During the ninth grade, only minimal sex differences were measured in math achievement between boys and girls, but in later grades large differences in math achievement were measured by Wise. The larger gains in math achievement by boys can be directly attributed to a greater participation by men in math courses and greater male interest in careers requiring a math background. This study was carried out in two phases. Phase one involved NSF Talent Search participants who were 9th graders in 1960 and the same students as 12th graders in 1963. Phase two surveyed the same people 1, 5, and 11 years after

high school graduation. The two strongest predictors of 12th grade math achievement were 9th grade math achievement ($r=.78$) and the amount of math taken in high school ($r=.73$). The amount of math taken and 9th grade math achievement together account for 71% of the variance of 12th grade math achievement. Wise concluded that the long range effects of math in high school play a significant role in the development of math-related careers over the entire period from high school to age 29.

Goldman and Hewitt (1976) have reported that mathematical ability appears to be an important factor for students in the choice of a scientific versus nonscientific field. Their study involved a sample of four college campuses using undergraduate college students (ranging from 3,658 to 7,385 students per campus) enrolled during the 1973-74 academic year. They reported finding statistically significant correlations ranging from .47 to .58 between students' major fields and scores on the SAT mathematical subtest. They concluded in their study that mathematical ability strongly influences the differences between men and women in the choice of scientific versus nonscientific fields. A solution to this problem, suggested by a few

researchers, is to increase the mathematical ability of college women by encouraging high school girls to study more mathematics (Goldman & Hewitt, 1976; Iker, 1980).

In "Women in Science" (1975) by NSF, it was stated that, in general, high school girls are still taking less mathematics and science than boys. However, at the University of Wisconsin, an NSF study by Fennema and Sherman found that, overall, there appear to be no significant differences between the sexes in the attitudes towards mathematics, with two exceptions: girls exhibited less confidence in their ability to learn mathematics and, secondly, boys more than girls stereotyped mathematics as a male domain. For girls, however, positive attitudes towards mathematics appeared to decline from grades 9 through 12 (cited in "Women in Science", 1975).

Contradicting the findings of Fennema and Sherman, Benbow and Stanley (1980), in a study involving 9927 intellectually gifted junior high students, found that there is a significant sex difference in mathematical reasoning ability, which favors boys over girls. They stated that their results contradict the usual explanation that sex-differences in mathematics ability is due to differential course enrollment. They observed

sizable sex differences in mathematical reasoning ability in 7th grade students. They assumed that, up to 7th grade, boys and girls receive the same amount of training in mathematics. Benbow and Stanley concluded that sex differences in achievement in mathematics may be related to greater male ability in spatial tasks. One might question in this study the validity of using the College Board Scholastic Aptitude Test (SAT) mathematics and verbal subtests for seventh and eighth graders.

Mary Gray (cited in Kolata, 1980) has indicated that too little is known about the development of mathematical reasoning ability and how to test for it. She feels that to jump to the conclusion that math sex differences are genetically based rather than solely a result of social factors is unreasonable. Kolata (1980) concluded that the influence of mathematics preparation for women going into S/E careers is an area that needs further research.

Recently, Dr. Alma E. Lantz and Gregory P. Smith (cited in Muldoon, 1980a) conducted a Denver Research Institute study surveying more than 1,500 high school students in Denver, San Francisco, and Rawlins, Wyoming to find out their attitudes towards mathematics. It was found that, despite discouraging advice from teachers, advisers, and friends, more high school girls than ever

are deciding to take extra math courses. This unpublished study suggested that past discrepancies in mathematics achievement between high school girls and boys are not due to sex differences in the ability to learn the subject, but due to societal pressures since mathematics has been generally considered as a male domain. It was found that the most important factor in a girl's decision to choose extra math is whether it will help her in a potential career. It was concluded that increases in the number of girls taking math indicates that girls may now have greater educational and career expectations in science and engineering.

S/E Career Programs for Women

Aldrich (1978), in a review of government sponsored programs, listed the major organizations involved in research on women in science. The major organizations were : The National Science Foundation, Scientific Manpower Commission, Commission on Human Resources of the National Academy of Sciences/National Research Council, a few associations, such as the American Chemical Society and the American Institute of Physics, and various other societies which provide information on women in science

and engineering.

The Association for Women in Science, Inc. (AWIS) has recently introduced a National Registry of Women in Science and Engineering, containing listings of more than 5,000 women. This organization offers a variety of services to women. These services are listed in their 1980 publication called "Resources for Women in Science" (Baizer, 1980). It includes job listings, career information, sources of financial aid and internships, minority and handicapped information, statistics on women in science, bibliographies of famous women in science, and opportunities for women through the federal government.

In 1974, the NSF funded eight experimental projects and in 1975, they funded an additional four projects relating to increasing the participation of women in careers of science and technology. Lantz and West (1977) have discussed and evaluated these projects and have come up with many useful conclusions and recommendations for future projects of this sort.

I will attempt to summarize some of the findings reported by Lantz and West (1977) dealing with the 12 NSF projects funded to increase the participation of women in science and engineering careers.

Four of the projects involved the use of active women scientists as role models for the women students involved in the program. Two of the programs involved college level women as the subjects; one of these programs developed and used multimedia packets of women scientists while the other used a film of women scientists in action. Lantz and West (1977) have reported that neither of these programs had significant results because the time span for the study was too short. With high school girls as the participants, two programs involving women scientists as role models were conducted. Since the students selected for comparison were not randomly assigned, neither of the programs was able to detect statistically significant differences between the group that received the treatment as compared to the group that didn't. The treatment was the influence of women scientists as sex-role models. Therefore, it was difficult to make statistical inferences from the results.

Four of the twelve NSF programs reviewed by Lantz and West involved the use of career materials. The career materials used were developed to help women subjects become more aware of the known career barriers to women going on into science and engineering careers.

Two of the programs involved women college students and the other two involved secondary school girls. One of the college programs was carried out at the University of Kansas. Besides involving the women, this program involved the parents of the girls. Significant differences between the control and experimental group were reported. Approximately 300 women, consisting of two separate classes seeking admission to the university in the Fall of 1974 and 1975, who had the ability but did not plan on a science career participated in the program. The experimental group received the treatment, which involved the students and their parents participating in workshops on science and engineering careers on campus. The experimental group also worked on a home course of study involving careers. The control group did not receive any of the treatment. Both the control group and experimental group completed a questionnaire to measure their interest in science careers, before and after the program. It was found that more women in the experimental group stated they planned to pursue related careers in science than in the control group (48.6% to 28.5%). The female students involved in this study ranked the difficulty of combining a science career with a family as the greatest barrier to their science career

plans. The results of the second college program were not available.

The two secondary school programs involving the use of career materials to increase the girls' awareness of science barriers reported either no significant results or problems in their program design.

Two of the programs, one with college girls and the other with secondary girls, centered around the idea of having the girls participate in various activities. The college program involved the use of an experimental mathematics project with the hope of updating the math skills of the women, thereby increasing their chances of pursuing science-related careers. The secondary school project involved problem-solving activities which were hoped to increase interest in science careers. Neither of the programs was able to report results because of design problems.

One of the NSF programs involved women who had already earned bachelor's degrees in chemistry but were not presently employed. The idea was to update their skills to make them employable. Unfortunately the program designers did not check to see if there were jobs available in the area for the women involved in the program. Therefore upon completion of the program, many

of the women were not able to be placed in chemistry jobs.

The last NSF program involved the cooperation of secondary school science teachers and counselors in group science career projects. The program's purpose was to increase the S/E career awareness of the teachers and counselors of for women. All of the 36 participants reported in a questionnaire that the program was of value; unfortunately, no follow-up study was done to see if the program affected the participants enough for them to influence the female students they teach and/or counsel at their respective schools.

Lantz and West (1977) concluded that many of these projects proved to be ineffective as judged by statistical methods, because of various problems. They recommended that, in future studies, four considerations be made: (a) limit the number of variables used, (b) make sure the project is designed so that it relates to science careers, if that is the purpose of the study, (c) use care in selection of control groups, and (d) be certain that the factors to be investigated are more selective and can be measured with some reliability.

In 1978, three additional NSF funded programs were developed with the purpose of influencing women's career

choices to science and engineering. Weiss, Place, and Conaway (1978) developed a program in which 40 women scientists visited 110 high schools in the United States. Female students in the 10th grade were randomly assigned to various groups. A variety of program influences were given to the girls in order to supply them with role models, examples of science careers in which women were involved, job opportunities, preparation information, access to additional information, etc. It was found that a single visit by one woman scientist would not be enough, so students were encouraged to ask for more information. It was found that the experimental groups which received the entire program of influences requested more information by postcard than the control group (21% to 6%, statistically significant at the .05 level). Of the students requesting information, 88% specifically asked for information on job opportunities for women in science and technology. It was found that 57% of the experimental schools had more than the usual number of girls requesting information about science careers as opposed to 38% of the control schools. A high percentage of the students evaluated the program as good to excellent and 91% of the schools said they would participate in the future.

Smith and Stroup (1978) have developed a science career exploration activity program consisting of six modules. The program is aimed at science teachers, counselors, and others who work with talented young women of high school and college age. No results of the use of the program are available at this time.

The National Science Foundation announced for 1980-81 that they granted 23 awards, totaling \$1,021,011, aimed at increasing the number of women in scientific and technical fields. These programs consisted of 17 Science Career Workshops and 6 Science Career Facilitation projects. These programs were to be conducted in 16 states at various colleges, universities and other organizations. The plans for the workshops were to advise women how to prepare for careers in science and engineering by presenting information about employment opportunities. The career facilitation project goals were to provide training for women with a bachelor's degree in science, mathematics or engineering who were not employed in technical fields at present, so that they may be ready to enter the job market or go directly to graduate school (Muldoon, 1980b).

Lantz and West (1977) have done an impact analysis of the various 1974-75 NSF sponsored programs to increase

women participation in careers of science and technology. They have suggested some final conclusions and have made some recommendations for future studies of this nature. They are listed below:

1. More women scientists should be used in the programs as models.
2. The programs would be better served if they were geared to high ability women.
3. New programs should be offered with the idea of reinforcing the effects of earlier programs.
4. Women students should be introduced to the uncommon fields, such as electronics, video technology, audio-technology, flight, and computers.
5. The projects should concentrate on women already interested in science.
6. Workshops should be used in which subjects live-in for a extended period of time.
7. Participant interaction should be encouraged.
8. Longer contact periods between models and students should be used.
9. The participants should be given hands-on experiences in science and engineering.
10. The projects should emphasize the social contributions of science, especially those by women.

11. The removal of institutional barriers to female participation in science careers should be emphasized.

12. The importance of continuing mathematics preparation should be considered.

13. The projects should concentrate on underemployed women.

14. Employment prospects in an area should be considered before starting a project to increase women employment in science.

15. Projects to update job related skills in science and engineering should be included.

16. Special seminars, workshops, and counseling for women should be developed.

17. Standardized evaluation tools and long term tracking should be included, if possible.

18. Some specific programs for minority women should be instituted.

19. NSF and sponsoring agencies should be more selective in funding of projects and should supply technical assistance to project directors.

20. All ongoing programs should be coordinated.

21. Project coordinators should investigate materials that have already been developed by earlier projects before attempting to develop new materials.

22. Systematic investigations should be carried out considering: (a) the effects of grouping female students in the absence of male student influence, (b) the attitudes of men toward women scientists, and (c) the effect of others, such as parents, school personnel, male peers, and female peers on attitudes.

The Factors that Influence Student Science and
Engineering Career Interests

Teacher Effectiveness as a Factor

Teacher Effectiveness in General. Rosenshine (cited in Houston, 1974) stated that the nine most promising variables for future research on teacher effectiveness are the clarity of a teacher's presentation, variety of teacher-initiated activities, enthusiasm of the teacher, teacher emphasis on learning and achievement, avoidance of extreme criticism, positive response to students, student opportunity to learn criterion material, use of structuring comments by a teacher, and the use of multiple levels of questions or cognitive discourse. These nine variables were selected as the most promising on the basis of research studies to date. Each of these

variables was selected because it has been shown to be significantly related to pupil achievement.

Rosenshine has also listed those variables which have not been known to be significant or consistent with achievement. These variables include non-verbal approval, praise, teacher warmth, ratio of all indirect to all direct behaviors, number of questions, questions classified into two levels, teacher talk, student talk, teacher experience, and teacher attitude toward subject matter. Rosenshine also gave a list of variables in which very few studies have been done at all. Those that relate to my research study are developing pupil self-concept, selecting instructional strategies, explaining subject matter, and using inductive and deductive strategies. He stated that there are not enough studies about the relationship between teaching competency and pupil achievement. No mention of student interest as an outcome of teacher effectiveness was made.

Soar (cited in Houston, 1974) has concluded that the major problem with research on teacher effectiveness involving the classroom has been the limited statistical power of the studies. Generally, the studies involve so few teachers that these studies are not taken as seriously by researchers as studies with higher power.

In evaluating teacher effectiveness, McNeil and Popham (1973) have stated that "Work habits, years taught, degrees held, grades received and ethnic background are pedagogically weak variables" (p. 227). They concluded that effectiveness of a teacher should be measured by the individual's competency to produce changes in learners. Therefore, it is necessary to define the changes with which we are concerned.

Numerous reviews and papers have been written involving teacher performance and effectiveness (Brophy, 1979; Centra & Potter, 1980; Coker, Medley & Soar, 1980; Houston, 1974; McNeil & Popham, 1973; Orstein & Levine, 1981; Rosenshine, 1976; Rosenshine & Furst, 1973; Taylor, 1981).

Lanier (1978) summarized the basic state of the research on effective teaching by stating that earlier studies centered on how to identify teacher actions that distinguished effective from ineffective teachers. She feels that too much emphasis was placed on the identification of skills and/or performances that affect the pupils and the emphasis should be placed on how teachers decide what will be done in the classrooms and why. Schwab (1962) has identified the four major areas that should be researched in teacher effectiveness.

These include: (a) the teacher, with his/her particular knowledge, skills and tendencies; (b) the particular learners; (c) the subject being taught, and finally (d) the environment in which the instruction occurs.

Science Teacher Effectiveness. Over the past 15 years, the National Association of Biology Teachers (NABT) has engaged in a program to evaluate biology teacher effectiveness for its "Outstanding Biology Teacher Award" (OBTA). In order to gain insight into how biology teachers were evaluated, Dieter and Hounshell (1975) asked the judges of the 1970 OBTA program to rate the criteria they used for evaluating these teachers. The study involved 220 members of the 47 state selection committees. The occupational groups represented in these 220 judges consisted of college biologists, secondary school biology teachers, college professors of science education, state science supervisors, secondary school administrators, industrial biologists, local science supervisors and a few other science related occupations.

Of the 111 factors rated, 21 of these were found to be significantly more important, than the others, by the total group. The significant factors reported by Dieter and Hounshell (1975) were:

1. Interest and enthusiasm for biology
2. Ability to encourage self-motivation in students
3. Concerns for students understanding of essential concepts
4. Ability to inspire self-confidence in students
5. Concerns for student understanding of essential science processes
6. Evidence of resourcefulness
7. Adequacy of self-concept
8. Concern for personal involvement of student learning activities
9. Evidence of ingenuity
10. Emotional poise and self-confidence
11. Evidences of creativity
12. Apparent interest in self-improvement
13. Habits of dress, voice, mannerisms, speech
14. Activities and accomplishments
15. Provisions for differing student interest and abilities
16. Laboratory experiences characterized by thought-provoking problems
17. Efforts to encourage student development of hypotheses and theories
18. Favorable perceptions by students and parents

19. Facilitating worthwhile student interaction

20. Ability to develop a classroom climate conducive to learning

21. Perceptions of individual student needs

Interest and enthusiasm for biology was rated as the most important factor in teacher effectiveness, which agrees with findings of other researchers (Brophy & Good, 1974; Bybee, 1973). Other criteria found, by Dieter and Hounshell (1975) not to be statistically significant included academic course experience, degrees, grades received in college, location and size of school, years of teaching experience, candidates' teaching and managerial efficiency, number of publications, number of honors or awards, or appearance of classroom or laboratory. It is interesting to note that of the 58 secondary school teachers involved as judges, concerns for student understanding of essential science processes, and concerns for student understandings of the essential concepts were rated important by 93 and 90 percent of the teachers, respectively. In almost every occupational group of the judges, concern for student understanding of science was rated important. Dieter and Hounshell concluded that it is possible to say that specific teacher effectiveness criteria do exist which are

statistically significant to competent judges.

In reviewing several studies comparing the lecture-discussion method of teaching science against other methods, Ramsey and Howe (1969) found that generally no one teaching method was superior to another. They then stated that teacher variability and characteristics may influence class learning far more than external arrangements such as method. They concluded, in their study of research in instructional procedures in secondary school science, that the nature of the course and the background and experience of the teacher both seem to affect the gain in a student's understanding of science. They feel that the relationship between student and teacher understanding of science needs further investigation.

Perkes (1967-68) reported in a study of 32 junior high science teachers and 3,062 students that teacher-oriented activities (talking, demonstrating, etc.) correlated positively (.36 to .70) with scores on factual tests and negatively (-.40 to -.66) with scores on application tests. Student-oriented activities, like discussion, laboratory participation, etc., were positively related to high scores on application tests ($r=.47$ to $.70$) and negatively related to scores on

factual tests ($r = -.33$ to $-.54$). It can be concluded from Perkes' results that a more effective teaching method in science classes may be a balance of student and teacher centered activities to maximize factual and application learning in students.

In a study of the characteristics of 35 physics teachers and the learning of their 2000 students, the following conclusion was reached by Rothman, Welch and Walberg (1969):

Teachers' personalities and value systems are more strongly related to students' changes in physics achievement, attitude toward physics, and interest in science than are the extent of teachers' preparation in physics, mathematics, and the history and philosophy of science, their knowledge of physics and their years of physics teaching experience. (p.63)

Rothman (1969) concluded in a study of physics teachers and their students that the "teacher effect" cannot be attributed to any one factor, but involves the interaction of several different teacher characteristics. He suggested that what is needed is to match teachers and students in terms of relevant characteristics in order to maximize the effectiveness of the student-teacher

interaction in learning.

It was discovered in several studies that the perceived adequacy of personal relations with students and enthusiasm in working with students are the two most important qualities of the ideal science teacher. The third most important teacher characteristic involves the adequacy of teaching methods and class procedures, followed by knowledge of subject matter and adequate planning and organization (Bybee, 1978; Dieter & Hounshell, 1973; Reed, 1961). After reviewing close to 200 research studies dealing with teacher effectiveness, Bybee (1978) has arrived at two major conclusions:

1. The personal qualities of teachers are perceived by science educators as important measures of effective science teaching.

2. "There is not a definable characteristic or set of characteristics which contributes to effective teaching" (p. 22).

Bybee finally suggested "that teaching science effectively is a function of the teacher's unique ability to adapt knowledge, personal relations, planning, enthusiasm and methods individually and in toto to situations in his or her classroom" (p. 22).

Hasan (1975), after investigating 340 eleventh

graders in Jordan, concluded the following:

If the development of science interest is desired, then one can, on the basis of this study, pinpoint the most suitable characteristics of the secondary school science program. It is a program in which science teachers are concerned with students' questions, science reading and activities, and vocational choice, and in which they show personal interest in the science learning of their students. In addition, it is a program that includes a component of the social importance of science, encourages students to participate in appropriate science activities, and also helps students to develop confidence in their abilities to study science. (p. 260)

The three measures of science teacher effectiveness investigated in my research were the science teacher's (a) classroom laboratory emphasis, (b) level of understanding of science, and (c) career interest. These three characteristics will be discussed in the following paragraphs.

1. The Science Teacher's Classroom Laboratory Emphasis. Hurd (1961, cited in Blosser, 1981) reported that in 1948 the science committee of the National

Education Association recommended that high school science courses should contain four hours of laboratory work a week, with all laboratory periods being two hours long, and two periods of recitation-demonstration instruction. Much later, in 1938, teacher demonstration appeared to be more economical in reference to time and money. The learning of science by the laboratory method was not shown to be superior. Because of this, many schools dropped the double laboratory period (Blosser, 1981). During the period of 1950-1970 with the establishment of the National Science Foundation, and with the launch of Sputnik, increased interest in the use of laboratory activities in the science classroom occurred (Blosser, 1981).

Recently, Rudman (1978) has reported a decrease in interest in science in general in the public schools. Because of the emphasis on the basics, science is no longer viewed as an important subject. Gardner (1979) reports that she sees as a major trend in science education the decrease of labwork in favor of demonstrations and deskwork. She feels that the reason for the decrease in laboratory involvement by students is mostly related to economics. With decreasing school budgets and the high cost of science materials,

"hands-on" work will be replaced by other experiences, such as demonstrations and seat work.

McNeil and Popham (1973) state that a fair and useful measure of teacher effectiveness is the manipulation of environmental elements in the classroom. Most science teachers will say that use of laboratory by students is one way in which teachers can control the class environment.

Pennington (1960), in a study of 502 high school seniors, reported that students were most likely to be interested in science if they had the opportunity to do laboratory exercises as part of their science class.

In a study by Weiss (1978) for the National Science Foundation, 355 seventh through ninth grade science teachers were surveyed. Some interesting results were discovered about teachers' use of various teaching methods in their classes. The most frequently used daily teaching methods reported were discussion (56%), followed by lecture (30%), student involvement in hands-on or manipulative or laboratory materials (24%), and individual assignments (23%). It was reported that student involvement in laboratory activities occurred just about daily by 24% of the teachers and at least once a week by 37% of the reporting teachers. This also means

be communicated by other teaching methods.

Two reviews of the role of the laboratory in secondary school science by Bates (1978) and Blosser (1981) have put together the major research available today dealing with laboratory teaching. Blosser (1981) stated that "although this is another assumption science educators cherish (participation in laboratory activities develops interest in science or increases those interests already present), the six studies related to this variable all produced no significant difference" (p. 63). Unfortunately, Blosser did not list these studies in an easily accessible way to discover which studies they were. In the studies involving interests in science as influenced by laboratory work in the classroom (Ben-Zvi, Hofstein, Samuel & Keapa, 1976; Bybee, 1970; Dearden, 1962; Lawrenz, 1976; Napier, 1969; Palla & Sherman, 1969; Yager, Engen & Snider, 1969), none of them found any differences in interests between groups doing laboratory activities and those not doing laboratory activities. Only one of these studies involved science student career interest (Palla & Sherman, 1969). The other studies investigated interests in science with interests being defined as whether students like one method better than another or liked science more or less after the

that 39% of the reporting teachers used laboratory activities less than once a week or not at all. In this report there was no mention about how much time was spent in laboratory activities per class. It is possible that the amount of time per day may range from several minutes to a full period. Some educators such as Roney (1969) have concluded that at least half the class time should be spent in activities and laboratory exercises. Others, such as the Organization for Economic Cooperation and Development (cited in Shulman & Tamir, 1973) and Novak (1970), have concluded that one third of the classes or one laboratory period or field trip per week is sufficient. Ausubel (1968) has mentioned that laboratory is so time consuming and inefficient that its use should be limited to only instructing students in the methods and spirit of science, while the textbook and teacher are the main source of the content of the discipline.

Numerous authors have stated that one of the major objectives of laboratory work is the development of the students' positive attitudes about science (Pella, 1961; Shulman & Tamir, 1973; Sund & Trowbridge, 1967; Tamir, 1976). Each of the above researchers generally agree that developing an interest in science is an important aspect of laboratory work that is not able to

treatment.

There are no studies available that looked at the relationship between science interest and science career interest. Since it is most pertinent to my study, only the research involving science career interest will be discussed. Using a nonrandomly selected sample of 100 8th grade science students in a so-called experimental design, Pella and Sherman (1969) looked at how lab work affected a number of variables with science career interests as one of these. The control group (manipulative) actually did laboratory exercises as part of their program, while the experimental group saw movies of the laboratory exercises. The two groups (control and experimental) were found to be significantly different ($p < .01$) in reference to science career interests at the beginning of the study and these differences were not controlled for statistically. The sample size of 100 was so small that the power of their being able to detect differences even if they did exist was much less than 50%. The science career interest was to be measured using the Kuder General Interest Survey Form E in a pretest-posttest format. Pella and Sherman reported that there was generally a decrease in science interest by students in both groups after instruction. If the groups

differed before instruction, it would seem that unless this difference was controlled for statistically, no conclusions can be reached at all. For Blosser (1981) to report that there was no difference between the groups in this study and that student career interest in science is not influenced by doing laboratory science is a misjudgement on her part. At the present time, the best that can be said about the relationship between laboratory work and science interests is that we don't know.

2. The Science Teacher's Understanding of Science. Applying Piagetian learning theory, Lawson and Renner (1975) have concluded that the teacher communicates the understanding of the discipline, such as science, through his/her own understanding of the discipline. This understanding can only be developed through an inquiry framework of laboratory work. Therefore, in order for a student to gain a true understanding of science, that understanding must be acquired from science teachers who understand the nature of science.

The science teacher's understanding of science, one of the independent variables to be used in this study, will be measured using the Test on Understanding Science (TOUS) developed by Cooley and Klopfer (1961). In an

extensive manual for the TDUS, Cooley and Klopfer describe its need, rationale, development, potential application, and other important information.

At the time they developed the TDUS, Cooley and Klopfer (1961) stated that there was a need to measure those aspects of science learning and teaching that promote understanding of the nature of scientific inquiry, of science as an institution, and scientists as people. It was the purpose of the authors to develop an instrument to measure this level of understanding by high school students. The test was divided into three main areas including: (a) understanding the scientific enterprise, (b) understanding about scientists, and (c) understanding about the methods and aims of science. The instrument was developed for use in research in science education. More detailed discussion of the TDUS can be found in Chapter III. Since my study only deals with teacher understanding of science, the literature related to teacher understanding and not student understanding of science will be discussed in the following paragraphs.

One of the potential applications of the TDUS stated by Cooley and Klopfer (1961) is to identify certain measurable characteristics that might be used to predict student interest in scientific careers. Cooley and

Klopfer (1961) state "Certainly the understanding which students have of science and scientists is a significant factor in their choice process" (p. 18). It would seem then that it would be reasonable to see what relationship there is between the teachers and their students' understanding of science. In one study by Rothman (1969) with a sample of 51 teachers selected at random from a list of 17,000 American physics teachers, he reported a correlation of .11 between the teachers' and their students' TDUS scores. This value has extremely low power. This is the only study in which the correlation of student and teacher TDUS scores has been studied. It would seem that this relationship should be investigated further.

In a review of the level of understanding of science of science teachers as measured by the TDUS, some interesting relationships have been determined. Several researchers reported that teachers' mean scores on the TDUS were considerably greater than the mean score for their students at 7-12th grade (Miller, 1963; Schmidt, 1967-68; Schmidt & Yager, 1966-67, cited in Schmidt, 1967-68). Miller (1963) discovered that 38% of high ability juniors and seniors in high school scored above 50% of the teachers in their study. This relationship is

also reported by Schaidt and Yager (1966-67, cited in Schaidt, 1967-68). If this is true, the reader may wonder whether the TDUS really measures understanding of science. Schaidt (1967-68) investigated this idea using three groups. They were college seniors in a secondary science methods course (N=29), sophomores involved in an elementary science survey (N=43) and working scientists from universities and industry (N=116). It was discovered that working scientists had the highest mean score on the TDUS (Mean=50.8), the college seniors second (Mean=48.0) and the sophomores in elementary science survey the lowest mean score (Mean=40.5). Schaidt, in his final statement concluded that perhaps the most important question that should be asked is how can science teachers at all levels better convey their understanding of science to their students (p. 366).

Yager (1966) reported in a study involving eight biology teachers who had similar academic backgrounds that there were significant differences between the classes of these teachers in their ability to understand science as measured by the TDUS. Yager admitted that some teachers are definitely more effective than others in enabling a student to grasp the meaning of science and the nature of science. Unfortunately the study did not

look at the teachers' scores on the TDUS as related to the students'. The sample size ($N=8$) of teachers was too small to draw reasonable conclusions. Similar results of teacher effect on students' understanding of science as measured by TDUS were reported by Zingaro and Collette (1967-68) involving 6 college instructors and 133 randomly assigned sophomore college science students.

Lavach (1969) in a study of 26 science teachers placed 11 in the experimental group and the other 15 in a reference group to evaluate an inservice program concerning the history of science. The two groups were set up so that each group contained teachers of similar academic and professional background. The experimental group received a total of 11 3-hour sessions on the history of science. The author did not report what the control group received. Lavach did report that the scores of the experimental group on the TDUS were significantly higher, at the .05 level. The teachers, in both groups, stated that the course provided them with a better understanding of the history of science and 10 out of 11 indicated their attitude toward the history of science had been positively influenced. In a preservice program of prospective elementary school teachers using two groups from different semesters, Olsted (1969) found

that preservice teachers' understanding of science as measured by the TDUS could be significantly increased ($p < .01$) when the preservice teachers were exposed to a process-oriented science program ($N=115$). Olstad (1969) has stated that "we must find ways of testing that through an increased understanding of science comes more effective classroom science teaching" (p. 11).

Groban (cited in Burps, 1972) has stated that since the development of the TDUS in 1961, the nature of the scientific enterprise has changed and the views of scientists have changed. He questioned the appropriateness of some of the questions on the TDUS at the present time. He has suggested that it needs to be updated and should be used with extreme caution.

I calculated a mean score on the TDUS for science teachers involved in a Florida Institute of Technology 1981 summer institute ($N=36$). The mean score was 43 correct of 60 possible answers. This mean score was very close to scores reported by Miller (1963) with a mean score for biology teachers of 43.6, and Schaidt and Yager (1966-67 cited in Schaidt, 1967-68) with a mean score for inservice science teachers of 43.5. It would seem reasonable that if the test was unreliable because it is outdated, then the scores over a 20 year period would

have greater differences between mean scores for science teachers tested in 1962-1968 and teachers tested in 1981. No significant difference was found between the scores of the teachers tested with the TDUS in 1962-1968 and those tested in 1981.

3. The Science Teacher's Career Interest. Several studies have concluded that teacher interest in teaching is an important factor in student interest in learning (Brophy & Good, 1974; Bybee, 1973; Dieter & Hounshell, 1975; Stedman & Breen, 1977).

Dieter and Hounshell (1975) conducted a study to determine the importance of various biology teacher characteristics for effective teaching. This study involved 220 judges associated with the selection of "Outstanding Biology Teacher" awarded by the National Association of Biology Teachers rating the importance of 111 teaching characteristics for effective teaching. The three teacher characteristics that were rated the highest for effective teaching by the judges were interest and enthusiasm for the subject and the ability to encourage self-motivation in students.

Stedman and Breen (1977) looked at the relationship between first grade teachers' natural science interest as measured by the Strong Vocational Interest Blank (SVIB),

and their students' natural science interests, as measured by the Survey of School Attitudes (SSA). This study involved 60 first grade students and 12 teachers. It was concluded by Stedman and Green that "the pupils that had teachers with high interest in natural science did score significantly higher on the SSA natural science scale than did pupils with teachers who had low interest in natural science" (p. 1093). This difference between the students of the two teacher groups was statistically significant ($p < .05$).

In my study, the science teachers' career interest in being a math-science teacher was measured using the Strong Campbell Interest Inventory (SCII) developed by Campbell (cited in Buros, 1978) from two earlier versions. These versions were the Strong Vocational Interest Blank for Men (SVIB-M) and for women (SVIB-W) and these were combined in 1974 to form a new unisex revised edition called the SCII (Buros, 1978). Further details about the SCII itself can be found in Chapter III under Instruments.

The SCII and the earlier versions, SVIB-M and SVIB-W, have been extensively studied by numerous researchers over the past 50 years. The SCII has only been used for 8 years and has been investigated in a

number of studies, none of them related to teachers. Burps (1978) lists over 1500 studies which have investigated these three vocational interest tests.

There are no studies at the present time that have looked at the relationship of student S/E career interest and the science teacher's career interest. There are a few studies that have used the SVIB with teachers, but none that used the SCII. The following studies deal with the use of the SVIB with teachers and the conclusions the researchers reached.

Belcastro (1975) used the SVIB to look at vocational factors that might be used as predictors of success in teacher education programs. He found that there are certain vocational factors that can discriminate between those who had completed a teacher education program and those who had not. Since his student sample was small, consisting of only 295 students while using 130 variables in a multiple linear regression analysis, the validity of his results are questionable. Webb (1976) used the SVIB in a multivariate study to see if there was a relationship between certain vocational variables and student teaching effectiveness. He found that the vocational variables as measured by the SVIB were not meaningfully related to the effectiveness of the student

teacher's performance as measured by supervisor ratings. Zaugra (1974), also using the SVIB, looked at the relationship of interest variables between student teachers and experienced teachers in grades one through twelve. He concluded in his study that the teachers in general had similar interest in helping-occupational roles and in self-expressive occupational roles but were not interested in the areas of technology and business.

The only other study using the SVIB with teachers was carried out by Stedman and Breen (1977). The results of this study were discussed earlier in this section.

Beizenherz (cited in Ochs, 1981) has suggested that many science teachers at the middle school level are not certified in science or they do not really want to be middle school science teachers. Because of this, they either lack interest, enthusiasm or commitment to teaching science or lose it along the way. Those who lose their interest do so because they have been misplaced into a career that does not match their capabilities and interests and this, in turn, influences their effectiveness as a science teacher.

It would seem, then, from the limited number of studies, that an investigation of the relationship of student S/E career interests and middle school science

teacher career interest is needed.

The Factors Besides Teacher Effectiveness

The Student and the School Environment. The term "interest in science" has been used to identify a wide range of meaning that ranges from good feelings about science to an in depth absorption into scientific investigation (Krathwohl, Bloom & Masia, 1960). Hasan (1975) has stated that the development of student interest in science has long been thought of as an important objective in school science programs.

In a study concerning the development of science interest in students, Welch (1969) suggested that there are two major considerations. The first consideration is that science is a basic component of general education for all students to survive in today's world. The second consideration is that our society demands technological development and this means scientific teaching must stimulate student interest in science to fill the needs for new scientists and engineers. Both of these considerations are very relevant at the present time.

Early research studies involved in these considerations have shown that interest in science seems

to be related to sex, science achievement, attitudes toward science, reasoning abilities, and hobbies practiced (Welch, 1969), while changes in interest are influenced by science teachers (Bingham, 1967-68; Neujahr & Hansen, 1970; Rothman et al., 1969). Student career interest in science as related to performing laboratory activities has been investigated in only one research study (Pella & Sherman, 1969), while the relationship between teacher's understanding of science and student S/E career interest has not been investigated to date.

Hardin and Dede (1973) reported that boys and girls are similar in both achievement and interest in science and mathematics until grade nine. At this point the interest and achievement of the girls decreases. It appears to Vockell and Lobonc (1981) that girls do not reject science in general, but their lack of interest occurs mainly in the physical sciences. This idea of similar interest of boys and girls in biological science, but different interest in physical science has been reported by earlier researchers (Hansen & Neujahr, 1974; Koelsche, 1965). In a study of coed schools versus non-coed schools, Vockell and Lobonc (1981) found that girls' lack of interest and negative attitudes toward physical science may be due to the presence of boys in

their classes. They reported that decreased interest in physical science may be due to interacting with males in science classes since, in their study, physical science was generally viewed as a masculine area.

Hasan (1975) investigated a variety of factors that may influence secondary school students' interests in science. His sample included 340 eleventh grade science students which consisted of 166 boys and 174 girls in Jordan. He concluded that boys with high interest in science as compared with boys with low interest participated more in science activities, had a better image of their science abilities, rated their teachers as better motivators, were more interested in science careers, and had more supportive parents. Female students with high interest in science as compared with those with low interest had parents who supported their interests, perceived science and scientists as more acceptable socially, had a better self image of their science abilities, and had a greater desire to pursue a science career. It was also found that the science teacher had the greatest effect on boys' interest in science while the social desirability of science influenced girls the most.

Wright and Hounshell (1981) surveyed 150 students

who were chosen because of interest and achievement in science to participate in the 1978 North Carolina Junior Science and Humanities Symposium. One hundred forty-seven students (79 boys and 68 girls) completed a questionnaire about their interest in science. A number of the conclusions that were reached are listed below with comments from related literature.

1. Science was chosen as the most interesting subject by the majority of boys and girls. Seventy three percent of the students reported high interest in science. The rest reported medium interest. Similar results were also reported in a study by Lindsay (1973) involving fifth and sixth grade students (N=734). Over 20 years ago, based on a cooperative project between Northwestern University and U.S. HEW Office of Education involving the course interests of students in grades 9-12, Witty (1961) found that science was generally rated as the least liked of all academic subjects. It was not mentioned how many students were surveyed but it seems that this involved a cross section of American youth at the time.

2. Boys' interest in science was significantly higher ($p < .01$) than girls'.

3. In reference to what age the students felt that

their interest in science developed, 13% reported before grade 1, 18% during grades 1-3, 21% during grades 4-6, 35% during grades 7-9, 13% during grades 11-12. Girls reported first interest predominantly in grades 7-9, while boys reported first interest as occurring during grades 4-6 and 7-9 equally. Boys generally became interested earlier than girls in science.

4. Seventy four percent of the students reported that their interest was developed through school, with school being more significant for girls than for boys.

5. Students rated high school science teachers as the most influential factor (71%), while junior high school teachers were rated second (49%) in developing science interests in the school environment.

6. Three-fourths of the students intended to pursue a major in science or science related fields in college.

7. Boys were significantly ($p < .01$) more interested in engineering than the girls, while girls were significantly ($p < .01$) more interested in medicine/health than boys.

The major highlight of the study was the importance of the high school and junior high school science teacher in stimulating interest in science in their high school students. The large impact of teachers on science

interest has also been reported by Lindsay (1973) who worked with 5th and 6th grade students.

It is interesting to note that a study similar to Wright and Hounshell's was done by Koelsche (1965) involving 54 award winning students attending the Junior Academy of Sciences in Georgia. Koelsche reported that interest in science developed in grades 4-8, with science teachers considered the major factors in stimulating student interest. Girls tended to become interested in biological science and boys in physical science. The major conclusion reached in this study was that the teacher holds the key to superior achievement and interest in his/her students (Koelsche, 1965).

In reference to the stability of students career interests during the secondary school years, it was discovered in two separate studies that secondary students' career interests are relatively stable. One study involving 68 secondary school students reported only a 21% change in career interest, as measured by the Kuder Preference Record using a test-retest situation (Wynn, 1963). In a 1980 study which used the Strong Campbell Interest Inventory, involving 70 students, 70% of the student career interest scores did not change from their freshman to senior year. It may be concluded

that interest is somewhat stable from 9th to 12th grade (Hansen & Stocco, 1980).

The Science Teacher as a Sex-Role Model. Kemper (1968) has defined a role model as a comparison group (or individual) which demonstrates to the individual how something is done.

O'Leary (1974), in a more expanded definition of a role model states:

The essential quality of the role model is that he (or she) possesses skills and displays techniques which the actor lacks (or thinks she lacks) and from which, by observation and comparison with his or her own performance, the actor can learn. Hence, in order for achievement to occur, the actor needs a role model to emulate. The role model does not motivate, influence, reward, or persuade the actor; the model merely provides a technical explanation of how the role is to be performed. (p. 818)

Numerous researchers have stated that the role of teachers in influencing 'girls' career interests is very important (Button & Brown, 1980; LaFitte, 1974; Malcom, Hall & Brown, 1976; O'Leary, 1974; Tidball, cited in "Women in Science", 1975; Trotter, 1976).

O'Leary (1974) has pointed out that the lack of female role models who have successfully combined marriage and family with a successful occupation has acted as a barrier to the occupational aspirations of women in general. Joesting and Joesting (1972) have suggested that having qualified female role models could enhance the self-image of women students. With a positive self-image, more women might pursue masculine-related positions (Shein, 1972).

Weiss (cited in Buccino, 1980), in a 1977 NSF study of Science Education in the United States, reported that there is a large difference in the percent of male and female teachers teaching science at the different grades. Weiss found that at the K-3 grade range, 98% of the science teachers are women (N=838), at the 4-6 grade range 67% of science teachers are women (N=829), at the 7-9 grade range 38% of the science teachers are women (N=1538), and finally at the 10-12 grade range 24% of the science teachers are women (N=1624). It is interesting to note that the percent of women teaching science decreases drastically at higher grade levels. It should also be pointed out that during grades K-3 (N=467), only 17 minutes per day were spent dealing with science, and at grades 4-6 (N=302) this value increased to 28 minutes

per day. Therefore the time (grades 7-9) when girls receive their maximum amount of science instruction, only 38% of the science teachers are women. When women science teachers are in the greatest percent, in grades K-6, the least amount of time is spent on science as compared to other subjects.

In a study of 10 female and 11 male elementary school teachers and their 734 students in grades 5 and 6, Lindsay (1973) reported that the teacher's sex was not a significant factor in science interest as measured by a questionnaire. In a more recent study of 40 elementary school teachers and their students, Fagot (1981) reported that male and female teachers' behaviors with elementary school children are statistically different ($p < .05$). Fagot did not look at the effect on the students but only on the difference of the behavior of the teacher in reference to the teacher's sex.

In their opinion, Sears and Feldman (1966) have suggested that parents start the process of teaching "sex roles" and that teachers continue this process when the child enters school.

Hardin and Dede (1973) have concluded that one of the major ways to actively counteract sexism in science careers and promote women to greater interest in science

careers is by recruiting more women science teachers in secondary schools.

At the secondary school level, there have been only a few studies that have investigated the influence of the teacher's sex on student achievement, attitudes, or interest. The following paragraphs deal with these studies.

Maccoby and Wilson (1957) found that students at the seventh grade level generally retained more information when influenced by a model of the same sex than by one of the opposite sex. In another study involving 10 women and 28 men general science teachers, Reed (1961) found that the sex of the teacher did not significantly affect the interest in science of their 1036 students. Interest in science was measured in a 70-item scale of the pupil's voluntary activities in science during the school year.

In the two most recent studies dealing with teachers as sex role models, Stake and Granger (1978) and Vockell and Lobonc (1981) have reported conflicting results. The study by Stake and Granger (1978) included a sample of 129 boys and 141 girls from senior high schools in Missouri. The teachers initially agreeing to be involved in the study consisted of 10 male and 10 female science teachers who had worked with these students on original

science research projects. The authors reported that only 14 of these teachers returned the questionnaire needed for the study. It should also be pointed out that the teachers were volunteers therefore they might not be representative of other science teachers. Using a Science Career Attitude Survey (SCAS) they had created, the researchers looked at the influence of the sex of the teacher on students of the same or different sex in reference to science career interest. The SCAS sections used in the study included measures of: (a) the sex of the teacher model, (b) the perceived attractiveness of the teacher model, (c) the amount of science-related contact between the student and teacher model, and (d) the student's commitment to a science career. Stake and Granger stated that "To determine the students' commitment to a science career, students were asked, 'To what extent would you like to have a career in science?' Students indicated the strength of their commitment on a 7-point scale" (p. 182). It was reported that in the interaction of sex of the teacher and sex of the student, the results were significant ($p < .02$). It was also reported that girls with female teacher models and boys with male teacher models had statistically higher science career commitment scores than girls with male teacher

models and boys with female teacher models. Stake and Granger (1978) concluded that students who have had same-sex teacher models had a greater science career commitment than those students with opposite-sex teacher models. It was also pointed out though that the degree of how strongly the students felt about their wanting to be like their model also made a difference.

Another conclusion reached by Stake and Granger was that the more contact time the students had with their model, the greater commitment the students had to science careers. It was suggested that since the number of female science teachers at the high school level is so small (23% in this study), this may be a factor that discourages girls from pursuing science careers. Stake and Granger suggested that an affirmative action program may be necessary to change the nonparticipation of women in science careers. Unfortunately, Stake and Granger did not report validity and reliability data for their Science Career Attitude Survey which makes their measuring of science career interest questionable. Another problem with this study is the low power since only a small number of teachers (N=14) were involved.

In reference to the influence of the sex of the science teacher on student interest in science but not in

career interest, Vockell and Lobonc (1981) reported different conclusions in a study of 1035 high school students. They predicted that, if sex-role modeling was important, schools with all female physical science teachers would display "more feminine ratings" toward science career fields than those with all male teachers. Feminine and masculine ratings were determined by giving the students a questionnaire which required them to rate 45 career fields related to a variety of academic disciplines. Each career field was rated as to the perceived degree of masculinity or femininity on a seven point scale. Vockell and Lobonc found no significant difference in the attitude of girls with all female science teachers and those with all male science teachers. It should be noted that this study did not look at career interest but whether the girls felt that a career field was masculine or feminine; therefore their conclusions are questionable for application to interest in science careers.

At the college level, Weishaar, Green, and Craighead (1981) reviewed the influences that affect the vocational choices of 18 women. Forty five percent of the women identified "no one" as a primary influencer of their vocational choice. Other influences which were

identified were 13.3% father, 12.3% high school teacher, and 7.9% mother. In reports of same-sex influencers, approximately 86% of male students reported they were influenced by men and of the female students, 58% reported they were influenced by men, while 38% were influenced by women. It was noted that a statistically significant number ($p < .01$) of the female students reported being influenced by women in their career choice. Weishaar, Green and Craighead's findings support the conclusion of other researchers (Bray & Howard, 1980; Brown, 1979; LaFitte, 1974; O'Leary, 1974).

There is a definite need for more research into the effects of the sex of science teachers on student career interest in science and engineering. This is especially true for girls.

Summary

A review of the literature relating the various factors that are barriers to women pursuing Science and Engineering careers has revealed conflicting opinions and conclusions by the various researchers. It is obvious that at the present time women represent only a small percent of the workforce in S/E careers. This includes

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One area in the literature that has not been investigated in great detail is the role of the secondary school science teacher in influencing girls interests in S/E careers. Numerous studies have been done looking at the relationship between teacher effectiveness and student achievement. But the relationship between teacher effectiveness and student career interest at the middle/junior high school level, especially in S/E careers, has not been investigated. It is generally agreed by the major researchers in science education that a major objective of teaching science is to increase student interest and career interest in S/E. Unfortunately, this relationship has not really been investigated in any great detail.

A variety of teacher effectiveness variables have been discussed as being related to student achievement. These same variables have not been investigated in reference to career interest. In a number of studies some of the variables that have been pointed out as important to be a successful science teacher include: teacher interest and enthusiasm, concern for students understanding of the concepts and processes of science, concern for personal involvement of students in learning activities, and providing laboratory experiences which

are thought-provoking. These characteristics are only a few of the important science teacher effectiveness factors, but these are of greatest importance to this study. Repeatedly in the literature, the science teacher was reported to be the key to student learning and interest in science. When students were asked who influenced them the greatest in their interest in S/E they stated that it was their "science teachers".

It is generally thought that the spirit of "What science is" and "What scientists do" is discovered by students in the various laboratory activities that they do. It is also recognized that, in most cases, it is the science teacher who determines the nature of the science curriculum. It has been pointed out that the teachers' understanding of the nature of science may influence the understanding of their students about science and scientists. The role of the laboratory in fostering S/E career interests in students, especially girls who normally have a lower interest than boys, has been investigated, but the studies have been so poorly designed that very little can be concluded. The best that can be said about the relationship between S/E career interests and involvement in laboratory activities is that we don't know what the relationship is. Even

less is known about the relationship between the percent of laboratory time spent in class and S/E career interests of secondary school students.

Science teacher career interest as a measure of teacher effectiveness in fostering student S/E career interest has not been investigated to date. It is generally thought that the teacher's interest in science does influence student learning and interest in science. Therefore, teacher career interest may influence student interest in S/E careers.

In the few studies that have investigated the science teacher as a sex-role model for S/E career interests of precollege students, especially for girls, the results were questionable. The only study that comes close to my proposed research was carried out by Stake and Granger (1978). Stake and Granger reported that students with same-sex science teacher models had a greater science career commitment than those students that did not. Earlier in this chapter, I pointed out that Stake and Granger's study had a few major problems that made their results questionable. These problems include: (a) a small sample of students and teachers, and (b) an instrument that has no reported validity or reliability values. This study directed its

investigation to high school students involved in original research projects. This group of students probably represents only those students that may already have a strong interest in science. In my study, I will overcome some of Stake and Granger's problems by using: (a) a larger sample of teachers and students, (b) a S/E career interest instrument that has been field tested and has both high reliability and validity, (c) middle and junior high school girls, at the eighth grade level rather than high school students, since the research indicates that at this level important initial decisions may be made that may affect future career aspirations, and (d) all of the eighth grade girls of each science teacher, rather than a selected group of students that may already be interested in S/E careers.

It should be pointed out that Stake and Granger's study looked at the influence of the science teacher's: (a) sex, (b) attractiveness as a model, and (c) amount of contact with the student, on high school students' career commitment to science. My study is somewhat different because it investigated the influence of the teacher's: (a) sex, and (b) teaching effectiveness on the S/E career interest of eighth grade girls.

Numerous researchers are of the opinion that the

lack of sex-role models in science and engineering for girls at the precollege level is an important factor that has limited the number of girls pursuing S/E careers. It may be concluded from the literature that since science teachers are considered to be an important influence and there are so few women teaching science at the precollege level, that the lack of women teaching science may be a major factor in women not pursuing S/E careers. Unfortunately the research has been so limited in this area that the true picture is not clear. Many of the reports in the literature have been based on conjecture and opinion and not on actual research.

It was the intention of this research study to investigate the relationship between the sex and effectiveness of the eighth grade science teacher and the S/E career interests of their female students, and to hopefully to shed some new light on this important aspect of science education.

CHAPTER III

RESEARCH DESIGN

Overview of the Study

This study had two major purposes. These purposes were: (a) to determine whether the interaction of the sex of the eighth grade science teacher and the sex of their eighth grade students was related to the S/E career interests of the eighth grade students, and (b) to determine if selected science teacher variables were related to the S/E career interests of their female eighth grade students. The study included one dependent variable, which is the CIS postsurvey scores of the science teacher's students on the Career Interest Survey, and six independent variables. These independent variables included: student CIS presurvey scores, student sex, teacher sex, and three measures of teacher effectiveness. The three measures of teacher effectiveness were: (a) the percent of time the teacher's students are involved in laboratory activities, (b) the teacher's level of understanding of science, and (c) the

teacher's career interest in being a math-science teacher. The results of this study are of value to science teachers and science educators attempting to develop student interest in S/E careers.

Population and Sample

The population for this study was the eighth grade science teachers employed in the state of Florida during the 1981-82 school year and their eighth grade students.

The sample included 30 eighth grade science teachers, who volunteered to be involved in this study and who are employed in eleven public middle and junior high schools and one K-8 parochial school located in Brevard and Indian River Counties in Florida. It should be mentioned here that the sample did not include four public middle and junior high schools, and a number of parochial schools also located in the two counties. For this proposed study, four of the public schools did not want to participate and the other parochial schools were not asked to participate. The sample also included 1937 eighth grade students (992 girls and 945 boys) attending these schools. These 1937 students included only those students that were present in the same science teachers

classroom for both the presurvey and the postsurvey.

Brevard and Indian River Counties are located on the east-central coast of Florida. The counties are approximately 60-90 miles east of Orlando, the nearest major metropolitan area. Brevard County consists of numerous small cities such as Titusville in the north, Cocoa, Cocoa Beach, and Merritt Island in the central area, and Melbourne in the south. The major city in Indian River County is Vero Beach. The Kennedy Space Center, Cape Canaveral, and Harris, Inc., a major industrial firm are also located in these counties. The counties contain Florida Institute of Technology, Brevard and Indian River Community Colleges, and branches of Rollins College and the University of Central Florida. The area is mainly suburban and growing in adult population.

Eighth grade girls and their teachers were chosen to be the subjects in this study for three reasons:

1. All eighth grade students usually take science, therefore enabling a larger sample of teachers and students to be gathered (Murray, Note 1).

2. Middle/junior high school is the time for students to choose their high school programs and whether they will elect to take more science. Since only one

year of high school science is required eighth and ninth grade may be a critical time for initial career decisions (Murray, Note 2).

3. By eighth and ninth grades, many students in the two counties may have considerably limited their future career choices (Schmidt, Note 3).

Data Procurement

This research study involved a presurvey and postsurvey. All of the eighth grade students were presurveyed to measure their career interest in science and engineering at the beginning of the year (during the first week of September). The presurvey was the Career Interest Survey (CIS) that I developed to measure the students' initial science and engineering career interest before any influence of the new science teacher occurred. The CIS was administered by each eighth grade science teacher following a standardized test administration procedure. By using a presurvey, I was able to statistically control for the initial differences of each science teacher's students. For each science student, the postsurvey score on the CIS was the dependent variable of the study. The postsurvey was administered

close to the end of the school year (during the first week of April, 1982).

The sex of the science teacher was the first independent variable considered. The other independent variables besides the sex of the teacher were the three measures of teacher effectiveness. These included: (a) the percent of time students spent doing laboratory activities as measured by classroom observations of each teacher using a modified form of Good and Brophy's (1978) form 10.1 Variety of Teaching Methods, (b) the teacher's understanding of the nature of science, as measured by the Test on Understanding Science (TOUS), and (c) the teacher's career interest in being a math-science teacher, as measured by the Strong Campbell Interest Inventory (SCII). Each of these instruments is discussed in greater detail in a later section of this chapter.

The testing of the teachers using the TOUS and SCII occurred during the month of March, 1982. The classroom observations occurred through the months of January to April, 1982. Each teacher was observed for at least four hours of classroom time.

Design

This research study employed a non-equivalent, control group design which involved the use of a presurvey and a postsurvey (Campbell & Stanley, 1963). The dependent variable was the CIS postsurvey scores for the eighth grade students of each eighth grade science teacher. The CIS presurvey scores for the eighth grade students of each eighth grade science teacher was used in the analysis to statistically control for the initial differences in S/E career interest of the eighth grade students for each teacher. The six independent variables which were statistically analyzed in two separate analyses were CIS presurvey scores, student sex, teacher sex, percent of laboratory time spent in the teacher's classroom, teacher's score on the TOUS and teacher's score on the SCII career interest instrument.

Data Treatment

The information obtained for each teacher is summarized in Table 1. Abbreviations for each of the variables used in the study are also given. These abbreviations are referred to later in this work.

Variables Used in This Study

Variable	Type of Variable	Abbreviation
Student Scores on S/E		
Career Interest CIS-Posttest	Dependent	CISPOST
Student Scores on S/E		
Career Interest CIS-Pretest	Independent ^a	CISPRE
Teacher's Sex	Independent	TSEX
Student's Sex	Independent	SSEX
Teacher's Sex X Student's Sex (Interaction Variable)	Independent	INTSEX
Teacher's Math-Science		
Teacher Career Interest	Independent	SCII
Teacher's Understanding of The Nature of Science (TOUS)	Independent	TOUS
Percent Time Students Were Involved in Classroom Laboratory Activities	Independent	LAB

^aUsed to statistically control for initial differences between teacher's students.

In this study, two separate statistical analyses were carried out. In the testing of null hypothesis one, a 2 X 2 ANOVA using multiple linear regression analysis was used, following the procedures described by Cohen & Cohen (1975). Null hypothesis one dealt with the interaction of the sex of the science teacher and the sex of the student, and the S/E career interests of the science students. In testing null hypotheses two through five, a multiple linear regression analysis was also performed, using a hierarchical ordering of the independent variables. Null hypotheses two through five dealt with the relationship between the final S/E career interest of the eighth grade girls and the sex and effectiveness of their science teacher.

I will define each of the variables used and then describe how each was treated before statistical analysis was undertaken.

CISPOST, the dependent variable, was the score on the CIS of the eighth grade students who were present during the postsurveying in April of 1982. The total number of questions in the CIS were 36. The last six questions of the CIS were used for determining concurrent validity of the CIS. The maximum score for career interest in S/E for any individual student is 50. The

raw score was used in this study. Scoring of the survey was done with a machine scorer at Florida Institute of Technology.

The following independent variables were utilized:

CISPRE - This was the score on the CIS of the eighth grade students present in the science classes during the presurvey in September, 1981. The maximum score was 50 for a student, as in the postsurvey. The purpose of this variable was to control statistically for initial differences in S/E career interest between the students of each science teacher.

TSEX - This was the sex of the teacher. For the analysis of null hypothesis one, a female teacher was entered as .5, while a male teacher was entered as -.5. For null hypotheses two through five, the women were entered as 1 and men as 0.

SSEX - This is the sex of the student. For null hypothesis one, girls are entered as .5 and boys as -.5.

LAB - This was the percent of time students spend doing laboratory activities in the teacher's science classroom. This was based on four to five hours of observation done during the months of January to April. The percent time was calculated by dividing the time in laboratory activities by total time, multiplied by 100.

This value was entered as a decimal.

TOUS - This was the raw score of the teacher on the Test on Understanding Science. It is a measure of the teachers' understanding of science as defined by Cooley and Klopfer (1961). The maximum score is 60. Therefore, the raw score of each teacher was used. This test was given to all teachers in March, 1982.

SCII - This was the score of the science teacher on the math-science teacher occupational scale as measured by the SCII. Teachers were dichotomized into one of two groups depending upon their standard score. Teachers entered as 1 were those whose scores indicated their career interests were similar to the SCII norm group. Teachers entered as 0 did not have scores similar to the norm group. This inventory was given to teachers in March, 1982.

The null hypotheses one through five on Table 2 were tested by using multiple linear regression analysis. SPSS (Statistical Package for the Social Sciences) was used for the data analyses (Nie, Hull, Jenkins, Steinbrenner and Bent, 1975). A 2 X 2 ANOVA and a hierarchical multiple linear regression were carried out using the VAX/VMS computer at the Interactive Computer Facilities of Florida Institute of Technology.

By using multiple linear regression analysis, it was possible to determine how much of the variance in the dependent variable was accounted for by each independent variable.

All tests of significance were performed at the .05 level. The probability of rejecting the null hypotheses if, in fact, they should be rejected, was calculated using the procedures of Cohen and Cohen (1975). The power to detect various effect sizes (as R-squared) for each hypothesis for a sample size of $N=60$ and $N=30$ and alpha at .05 is shown in Table 2. These power values indicate the probability of detecting statistically significant departures from the null hypothesis as large as the effect size (ES) indicated. Table 2 demonstrates for null hypothesis one, and this generally applies to the other hypotheses, that the tests have greater than 95% chance of detecting significant departures from the null hypothesis as large as $R\text{-squared}=.25$, while there is less than 12% chance of detecting differences as small as $R\text{-squared}=.02$ at an alpha level of .05.

For the testing of null hypothesis one, the dependent variable was the CIS postsurvey scores of the science students for each science teacher. The independent variables included the CISPRES scores, used to

Table 2

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Power for Null Hypotheses One to Five

Hypothesis	Number of Independent Variables	N	Effect Size (ES) as R^2		Power
1	4	60	.02		.12
			.13		.62
			.25		.95
2	2 ^a	30	.02		.12
			.13		.53
			.25		.86
3	3 ^a	30	.02		.10
			.13		.41
			.25		.77
4	4 ^a	30	.02		<.10
			.13		.35
			.25		.69
5	5 ^a	30	.02		<.10
			.13		.27
			.25		.56

^aIncludes the presurvey variable used to statistically control for initial S/E career interests of students.

statistically control for initial S/E career interests, TSEX (teacher sex), SSEX (student sex), and INTSEX (TSEX X SSEX). Following the procedures given by Cohen & Cohen (1975) the ordering of the independent variables for the 2 X 2 ANOVA using multiple linear regression analysis was CISPRES, followed by TSEX, SSEX, and finally INTSEX.

For the testing of null hypotheses two through five, the independent variables were entered into the multiple regression program hierarchically with each being entered in a predetermined order. This order, and reasons for the order, are given below for each independent variable.

CISPRES was entered in the regression first. It represented the presurvey scores for the student S/E career interest at the beginning of the study. This was entered first to statistically control for initial differences in the S/E career interests of students for each teacher.

TSEX was entered in the regression analysis second. It represented the sex of the science teacher. It was entered second, since the influence of teachers as sex role models for girls' S/E career interests was being investigated.

LAB was entered in the regression analysis third. It represented the percent of laboratory activities done

by the girls in their science teachers' classroom. It was entered third because it was a measure of what the students were actually doing in the classroom. This was entered here because it measures a direct influence of the teachers' instructional emphasis, which may affect girls' career interest.

TOUS was entered fourth. It represented the teacher's score on the Test on Understanding Science and was an indirect measure of teacher effectiveness. If it did effect students' S/E career interest, it was probably an indirect effect, since it may influence how the students view science and scientists.

SCII was entered last into the regression analysis. It was a measure of the teachers' career interest in being a math-science teacher as compared to math-science teachers that are satisfied and successful. It was considered an indirect measure of science teacher effectiveness, since it may not directly affect the girls, but measures a teacher's career interest in his/her occupation as compared to other math-science teachers that are satisfied and successful. This interest may influence how the teacher approaches his/her science instruction and in turn may influence student attitudes toward S/E careers.

Instruments

Teaching Evaluation: Variety of Teaching Methods

The instrument used to measure the percent of time students spend involved in laboratory activities was developed by Good and Brophy (1978). It is a modification of Form 10.1, Variety of Teaching Methods, given in their book "Looking in Classrooms". The instrument was designed to be used when a class is involved in classroom-related activities. The purpose of the instrument is to get an idea of the variety of methods used by teachers in class. The instrument is divided into two behavior categories, which are objectives and methods. The objectives included six items which state what the teacher is doing (for example, item #1 is "Introduce new material"). The methods included 15 items which involve what methods are used by the teacher to accomplish the objectives. A few of the methods included, for example, are #2, lecture; #5, questioning students to check understanding; and # 11, laboratory experiment or exercise.

The evaluator, using the six objectives stated and the 15 methods listed, records each time the teacher

changes activities in the class lesson. The evaluator is also expected to record the time and type of activity the students are doing. After the evaluation is over, the evaluator can then calculate the elapsed time spent in each classroom activity and can calculate the percent of the total lesson time in which the students were involved in laboratory activities. A laboratory activity is defined as including science classroom activities such as operation of a device, testing properties, finding physical properties, examination of structure, dissection, analysis, simple techniques, identification, preparation, controlled experiments, writing laboratory reports, discussion of results with classmates, related library research, etc. (Collette, 1973). In short, a laboratory activity is one in which the students are involved in manipulative skills or those activities that directly relate to these skills.

A copy of Good and Brophy's instrument is given in Appendix E.

The major reasons for my choice of this instrument for this research were that it was flexible and it enabled the evaluator to record a wide variety of teacher objectives and methods in a simple but efficient manner.

Test on Understanding Science - TOUS

Test on Understanding Science (TOUS) Form W was used to measure the level of each science teacher's understanding of the nature of science. The TOUS was developed by Cooley and Klopfer (1961) at the Harvard University Graduate School of Education. Form W, the form used in this research study, was developed as a research instrument to measure high school students' understanding of science and scientists. It has been used by numerous researchers since 1961 in research studies involving high school students, college students, and science teachers (Jerkins, 1969; Jones, 1969; Lavach, 1969; MacKay, 1971; Olstad, 1969; Schmidt, 1967-68; Yager, 1966; Zingaro & Collette, 1967-68).

Cooley and Klopfer (1961) developed this test "to measure the so-called 'intangible' aspects of science. These intangibles included an understanding of the nature of scientific inquiry, of science as an institution, and of scientists as people" (p.1). The test is divided into three major areas. These areas included understanding about the scientific enterprise, understanding about scientists, and understanding about the methods and areas of science. Each of these areas is also divided into

themes, with a total of 18 themes. The TOUS utilizes a four-alternative, multiple-choice item format consisting of a total of 60 questions.

There are no reliability and validity data reported in the manual for use with teachers, since the instrument was developed for use with high school students (Cooley & Klopfer, 1961). Lavach (1969), in a study involving 26 science teachers, calculated a reliability of .767 using the Kuder-Richardson Formula No. 20. I field tested the instrument during the summer of 1981 at Florida Institute of Technology with the purpose of gathering reliability data with a group of science teachers. The subjects included 36 secondary school science teachers involved in two special summer institutes offered to teachers for graduate credit. The calculated reliability correlation coefficient in a test-retest situation, with a week between tests, was ($N=36$) $r=.80$ ($p<.01$). Validity of the test is based upon the content analyses used as a structural basis for the test and upon the review of the test items by science educators, science teachers, and numerous professors of science and the history and philosophy of science (Cooley & Klopfer, 1961).

The test required 40 minutes of testing time. It can be scored by hand or by a machine scorer.

This instrument was chosen to be used in this study for three reasons:

1. It constitutes a reasonable attempt to measure an area of science instruction which is difficult to measure (Noll, cited in Buros, 1972).

2. Its ease of administration, simple method of scoring and short testing time make it a convenient instrument.

3. More importantly, it has been used successfully in numerous studies with science teachers (Cooley & Klopfer, 1961).

Strong Campbell Interest Inventory - SCII

The Strong Campbell Interest Inventory (SCII) was used to measure the math-science teacher career interest level of the eighth grade science teachers. The SCII is a revised unisex edition of the Strong Vocational Interest Blank for Men (SVIB-M) and for Women (SVIB-W). The SCII was developed in 1974, from the two earlier versions by David P. Campbell and is published by Stanford University Press. The instrument was developed to measure the occupational interests of people ages 16 years and over (Buros, 1978).

The SCII has been studied and used by numerous researchers over the past eight years. If the original SVIB editions are considered, the instrument has been used for over 50 years. Buros (1978) gives an extensive list of references, slightly over 1500, which report studies involving the use of the SCII and the SVIB-M and SVIB-W.

The SCII has 155 scoring scales. These scales include 6 general occupational themes, 23 basic interest scales, 124 occupational scales and 2 special scales. Also included are 23 administrative indexes. The entire inventory contains 325 items, in which the person responds by filling in either a "like", "indifferent" or "dislike" on the answer sheet. The SCII takes about 20-60 minutes to complete and it cannot be scored locally, therefore it must be scored by Consulting Psychologists Press, Inc. located in California (Buros, 1978).

In my research, I have only used the occupational scales, specifically the math-science teacher occupational scale, therefore I will confine the following comments to only that part of the SCII.

The SCII contains scores for 124 occupational scales. These scales were normed on occupational samples

of people currently involved in the particular occupation. The raw scores are converted to standard scores on the basis of the distribution of the sample (Campbell & Hansen, 1981). The occupational norm groups for each scale consisted of people with the following characteristics : (a) they were satisfied with their occupation, (b) they were somewhat successful, (c) they were between the ages of 25-55 years old, (d) they had at least 3 years of on the job experience, and (e) they were performing the occupation in the typical manner. For each occupational scale, the number of individuals used for each norm group was approximately 300 (Campbell & Hansen, 1981).

The standard scores on the occupational scales are determined differently for men and women using different norm groups. In general, the responses of a person on certain items are compared to the responses by the norm group. These scores, are then converted to standard scores which are printed out on a SCII profile sheet. According to the sex of the person and the standard scores, the person's occupational profile is then printed out and placed in a scale indicating whether the score was very dissimilar, dissimilar, moderately dissimilar, mid-range (average), moderately similar, similar or very

similar to members of the norm group. Of the total 325 items, 37 of the items are used to determine the math-science teacher standard score for men, and 54 of the items are used for determining the standard score for women for the same occupation (Campbell & Hansen, 1981).

In the 3rd edition of the Manual for the SVIR - SCII, Campbell and Hansen (1981) reported reliability scores for each occupational scale. Reliability of the occupational scales are reported as a test-retest correlation, with separate correlations for men and women. In the reliability studies, the retests occurred 2 weeks, 30 days, and 3 years later. For the math-science teacher occupational scale the reported reliability coefficients at 2 weeks, 30 days, and 3 years for men were .92, .86, and .88, while for women they were .94, .92, and .91.

The validity of test items is reported using both concurrent and predictive validity. Concurrent validity is estimated by determining the ability of the occupational scale to distinguish between people of different occupations. A percent overlap is determined between the criterion and reference samples. A large percent overlap indicates that the criterion sample and the reference sample are not different, therefore the

validity of the scale is low. A small percent overlap indicates that the criterion and reference samples are different, and this indicates a high validity. Occupations with low validities (high overlaps) are not considered to be well defined from other occupational scales. For the math-science teacher occupational scale, the reported percent overlap for men was 47%, while for women it was 40%. In comparison to the other occupational scales, the above values are in the mid-range for percent overlap indicating moderate validity (Campbell & Hansen, 1981).

The other measure of validity reported involved predictive validity. Campbell and Hansen (1981) define this as: "The predictive validity of an occupational scale is the scale's power to distinguish between people who will eventually enter different occupations" (p. 68). They base the predictive validity of the SCII on a 1972 study by Dolliver. Dolliver (cited in Campbell & Hansen, 1981) summarized 8 predictive validity studies that involved the SVIB. These studies ranged 7-18 years in length. Dolliver reported predictive validity results for the occupational scales of the SVIB. The predictive validity was reported by using the number of "good hits", "poor hits", and "clean misses". Good hits

were defined as those people who had standard scores that indicated their interests were similar to the occupation they eventually entered, poor hits had standard scores that mid-range, and clean misses were standard scores that were dissimilar to the persons eventual occupation. The "good hits" reported by Dolliver ranged from 42% to 61%. Diamond (cited in Buros, 1978) summarized the study by Dolliver by concluding that the hit rate is about 50%. Campbell and Hansen (1981) reported that in a recent study of college women and men, over a 3 1/2 years, that excellent predictive validity was found for 42.5% of the women and 59.3% of the men. This indicated to Campbell and Hansen, that the SCII predictive validity hit rates are approximately the same as the SVIB reported by Dolliver.

Dolliver (cited in Buros, 1978) has stated that "the SCII appears to the reviewer to be the best vocational interest inventory available" (p. 1626). Worthington and Dolliver (1977) concluded that the SCII has concurrent validity that surpasses the SVIB. They also concluded, on the basis of the data they had collected over an 18 year span, that counselors can use the SCII with as much confidence as they did with the SVIB. Worthington and Dolliver reported a "hit rate" for

the SCII of 55% for this study.

Career Interest Survey - CIS

The Career Interest Survey (CIS) Form B was used in this study to measure the science and engineering (S/E) career interests of the eighth grade girls.

Reasons for Development of CIS. The CIS was developed for use in my study because other tests did not meet my needs. The reasons this survey was developed were:

1. Currently, the major career interest tests used with middle school students include the Kuder General Interest Survey Form E (Kuder GIS) (Kuder, 1976), Planning Career Goals Interest Inventory (PCGII) (American Institutes for Research, 1975), JOB-O (Cutler et al., 1980a), and the Self Directed Search Form E (SDS) (Holland, 1979). These tests are all very expensive to purchase and machine score. Therefore, there was a need for an inexpensive test to measure S/E interest.

2. The currently popular career interest tests, such as the Kuder GIS, give nine scores with three of the interest scores listed as outdoor, computational, and

scientific. These all apply to various aspects of science and engineering career interests. In the PCGII, separate scores are given for the engineering/physical sciences group and medical/biological group. In the PCGII, as in the Kuder GIS, secondary school science teachers are not included in the science career interest score. In the JOB-O and SDS, as in many other career interest tests, the answer to the questions lead the examiner to different specific occupations. Through a selection process of likes and dislikes, background and future aspirations the student was led to specific jobs such as plumber, carpenter, zoologist, etc. that have been found to relate to the characteristics stated rather than to job groups (for example, S/E careers) as needed in my study. In this study, I am interested in the students' overall S/E career interest, not in specific S/E occupations. Because of the need for one score to be used in a correlational study to measure the S/E interest of students, the CIS was developed. The score includes all of the areas of the other career tests combined. Areas included in the CIS score include interest in medicine, biology, physical science, engineering, architecture, science teaching, etc and any other S/E career.

3. The four previous career interest tests discussed are lengthy tests and require at least one hour to complete, even though they state a shorter period of time in their manuals. Since teachers are very conscious of class time used in testing, there was a need for a test that requires a shorter testing time. The CIS in field testing was found to require only 20 to 30 minutes to complete.

4. The four tests, Kuder GIS, PCGII, JOB-O, and SDS are not specifically designed to measure S/E career interests. They are either set up to measure a wide variety of career interests or interests in a specific job. There was a need for a career interest test specific to S/E career interest.

5. There was a need to develop a S/E career interest test specifically for grades seven through nine.

Development and Field Testing. The CIS was developed and field tested during the summer of 1981. The Form B used in this research was the second form. The first form was called the Science and Engineering Career Interest Inventory (SECII). This was constructed using the PCGII, Kuder GIS, JOB-O and SDS as models in reference to format. It was decided to divide the test

into three parts containing a total of 61 questions. The first four questions in multiple-choice format asked the students to select choices in reference to their future high school program, amount of schooling they planned on pursuing and future job interest using major job categories. The next 56 questions listed occupational activities that scientists and engineers would do in their jobs. The occupational activities were developed by listing 56 of the possible science or engineering related careers listed in the four career tests or test manuals mentioned earlier (Cutler et al., 1980b; Flanagan, 1976; Holland, 1979; Kuder, 1971), and developing an activity that described each of these major S/E occupations. The students were expected to select whether they would like to do the activity, not like to do the activity, or weren't sure. The last question in this inventory requested the students to state in their own words their future occupational interest. The SECII was administered to 15 students in a science research class in a local high school. The students ranged from grades eight to twelve. The inventory only required 20 minutes to complete. It was found that many of the students who had interest in S/E careers had low scores on the inventory. It was discovered in talking with the

students afterwards that many of these students had already narrowed their career interests at this time. In the test, they expressed their interest only in the occupational activities that related to their stated interests. Therefore, an overall measure of the student's S/E career interests was impossible to determine. It was also discovered that using the title "Science and Engineering Career Interest Inventory", with the words science and engineering, immediately influenced some of the students' scores who did not express a liking for science or weren't sure of their opinion. Students were not given a choice of activities to select from in the SECII since they were all science and engineering activities. All of these reasons indicated that the test needed to be revised.

In the revision, the name of the career test was changed to Career Interest Survey (CIS). The format of the survey was also changed. The survey contains four parts. The entire survey, except for question #56, was set up using multiple-forced choice questions with three to five possible alternatives, depending on the part of the CIS. Question 56 asks the student to write his/her actual job interest on their answer sheet.

Part I consists of 30 questions which are titled

"Occupational Activities", in which the students were given three choices per question (two of the choices non-S/E and one S/E) in which they were asked to select the activity they would like to do the most. The S/E activities were taken from SECII and revised while the non-S/E activities were developed from a listing of non-S/E careers which were randomly assigned with each S/E activity. Part II contains 20 questions and was titled "Occupations". This part lists three occupations for each question (two non-S/E and one S/E) in which students were expected to choose the one they would like to do the most. Part III, titled "Present and Future", contains five questions in which students are expected to select a choice that describes their future high school program, select how much schooling they plan, pick the school subject they like the best, and select the job group where they feel their future occupation lies. Part IV contains one question which asked the students to state their actual job interest by writing it on the answer sheet. A copy of the Career Interest Survey (CIS) and an answer key can be found in Appendices B and C, respectively.

The purpose of Parts I and II of the CIS was to measure the S/E career interest of the student, using

specific activities and occupations. The purpose of Parts III and IV was to serve as a means of verification of the students score from the other two parts. Parts III and IV ask the student to answer questions that relate to whether the student understands some of the requirements of achieving a S/E career (for example, earning at least a 4 year college degree). Therefore, there was only one acceptable answer for questions #51-56, since the survey measures S/E career interest.

The student actually receives two scores from the CIS. The first two parts, called the S/E career interest score, has a maximum score of 50. The maximum score of Parts III and IV, called the verification score, was 6 since it contains only 6 questions. If a student score was high for the S/E career interest score it would be expected, if their score was valid, that their verification score would be high and vice versa. The statistical analysis to verify this relationship between the two scores is discussed later in this chapter.

During its development, the CIS was administered to 15 seventh through ninth grade girls involved in a majorette workshop offered at F.I.T. The students were from all over the U.S.. In talking to the students after they completed the CIS, the girls all said the reading

was easily understood as were the directions. Since the students were volunteers, no statistical analysis will be reported, but it was discovered that the survey did distinguish between those girls desiring a future job in science and those girls who did not.

After the second field test, a manual was developed to give directions for administering the CIS so that future administrations of the test would be consistent. A copy of the manual is in Appendix D. It was also decided at this time that a machine score answer sheet would be used for future testing.

Determination of Validity and Reliability. In September of 1981, at a Brevard County, Florida middle school, the CIS was tested for the purpose of gathering reliability and validity data. The school involved in this part of the CIS development has a student body of 860 students and consists of seventh, eighth, and ninth grade students. It was centrally located in the county and was similar to the other middle/junior high schools in the area. It was an ideal school for such testing.

The number of students needed for validity and reliability values was determined using the power analysis method reported in Cohen (1977). Setting

alpha=.05 and power=.80, I determined that I would need at least 42 students in the collection of validity and reliability data. The CIS was validated against the Kuder GIS Form E which has been used in schools since 1964 and is an extension of the Kuder Preference Record - Vocational, Form C which has been used in secondary schools for close to 40 years (Buros, 1972). The score of the CIS was the first 50 questions found in Part I and Part II which gives a maximum score of 50. The score used from the Kuder GIS was the percentile score for the scientific part of the survey. The raw scores of the Kuder were calculated and then converted to normative percentiles which depended upon each student's grade and sex. The CIS was administered during the second week of school by the business teacher to 60 students in grades seven through nine. After one week, these same students were given the Kuder GIS Form E. The scores for only 45 of the 60 students could be used since 15 of the students either were not present for the second testing because they were absent or they transferred to another class, or their scores for the tests were dropped because the V scale of the Kuder was higher than the limit of 15. A V scale score higher than 15 indicates that something went wrong in the testing and the value of the score was

questionable (Kuder, 1976). The 45 student scores used included 20 seventh graders, 6 eighth graders, and 19 ninth graders. This group of 45 students included 17 boys and 28 girls. Concurrent validity of the CIS with the Kuder GIS was .75 ($N=45$). The mean raw score for the CIS was 18.2, while the mean percentile score for the Kuder GIS was 46.5 ($N=45$).

I was able to calculate another measure of concurrent validity for my survey. In order to do this I correlated the CIS S/E career interest scores, of the students used in both the validity and reliability testing, with their verification score. Using scores of 127 students (84 girls, 43 boys) in grades seven through nine I calculated a correlation coefficient of .59. The mean raw score for the CIS for the 127 students was 20.2. It should be mentioned that there were actually 136 students, but because 9 of the students didn't answer question #56 they were not included in the calculations. I may conclude that there was a significantly positive relationship between the two scores on the CIS. Students who score high on the S/E career interest part of the survey also should score high on the verification part of the CIS.

The determination of the reliability coefficient of

the CIS was done at the same school as the validity analysis. The test-retest method was used with a one week period in between the testing. In both testings, the CIS was administered by the classroom teacher in his business classes. Initially, 76 students in grades seven through nine were given the CIS during the second week of school. Only 57 students were able to take the retest because of absences and class transfers. The 57 students included 22 seventh graders, 4 eighth graders, and 31 ninth graders. The breakdown of student sex was 36 girls and 19 boys. The test-retest reliability estimates for the students (N=57) was .96. The mean scores for the CIS, on the test-retest, for the 57 students were 20.7 and 21.8, respectively.

Both the reliability and validity coefficients were reasonably high, indicating the CIS was both a reliable and valid measure of student S/E career interest.

CHAPTER IV

THE DATA AND STATISTICAL ANALYSIS

Purpose

The purpose of this study was to determine whether the sex and other select characteristics of science teachers contributed significantly to the variability of eighth grade students' science and engineering career interests. The dependent variable of this study was the postsurvey scores of the science teachers' students as measured by the CIS. The results are reported in two major sections. The first section of this chapter reports the results of the statistical analysis used to test null hypothesis one. The results of this section report the amount of variance in eighth grade boys' and girls' S/E career interests that is accounted for by the interaction of the sex of their science teachers.

The second section of this chapter reports the results of the statistical testing of null hypotheses two through five. This section deals with the amount of variance of eighth grade girls' S/E career interests that

is accounted for by the effectiveness of the science instruction as measured by the teacher's (a) classroom laboratory emphasis, (b) level of understanding of science, and (c) level of career interest in being a math-science teacher.

The data were analyzed using the multiple linear regression analysis program of the Statistical Package for the Social Sciences (SPSS). The statistical analysis for the testing of null hypothesis one involved the use of a 2 X 2 ANOVA. The statistical testing of null hypotheses two through five involved the use of hierarchical ordering of the variables in multiple linear regression analysis.

General Results and Comments

Of the original 3033 eighth grade students involved in this study, only 1937 of these students could be included in the statistical analysis. It was found that, in the schools involved, students frequently move in and out of the area. Because of the transient nature of the student sample, only those students that took both the pretest and posttest with the same science teacher were used in the analyses. Appendix A lists the mean pre- and

postsurvey scores for boys and girls for each teacher but, more importantly, indicates that there were significant differences in the number of eighth grade students for each teacher. Therefore, in the statistical analysis for all of the null hypotheses, each student was entered into the regression analyses as a separate case to correct for the different number of students of each teacher. Consequently, a weighting factor was used to correct for these differences, by using the number of teachers (30) for degrees of freedom instead of the number of students (1937), since this is primarily a teacher study.

Table 3 displays the means, standard deviations and N for the pre- and postsurvey CIS scores for all students, for girls only and for boys only.

Results of Interaction Analysis

A 2 X 2 ANOVA using multiple linear regression analysis was performed to test null hypothesis one. The analysis consisted of two different regression analyses. The first analysis consisted of regressing the teachers' sex, students' sex and the interaction term (teachers' sex X students' sex) with the CIS postsurvey scores of

Table 3

CIS Mean Scores, Standard Deviation and Sample Size
For Eighth Grade Boys and Girls

Students	Survey Time	Mean	Standard Deviation	N of Cases
All	CISPRE	19.0	9.5	1937
	CISPOST	18.1	9.3	1937
Girls Only	CISPRE	16.4	9.2	992
	CISPOST	15.8	9.0	992
Boys Only	CISPRE	21.8	9.0	945
	CISPOST	20.7	8.9	945

the eighth grade students. The second analysis included the same variables listed above but also included the student presurvey scores as a covariate. The purpose of entering the presurvey score in this regression analysis was to partial out the amount of S/E career interest the students had at the beginning of the year.

Table 4 represents the correlation matrix generated by the SPSS Program in which each variable is correlated with each of the other variables. It is important to point out the statistically significant correlation of .78 ($p < .05$) between the presurvey and postsurvey scores. Also, the correlation coefficients between student sex and both the CIS presurvey scores ($r = -.28$) and postsurvey scores ($r = -.26$) are statistically significant ($p < .05$). The negative correlation here indicates that boys generally had higher scores on the CIS than did girls. None of the other correlation coefficients were statistically significant.

Table 5 is the multiple linear regression summary table for the interaction of the sex of the teacher and the sex of the student, with CISPOST as the dependent variable. This regression analysis included the CIS postsurvey as the dependent variable and teacher's sex, student's sex and the interaction term (teacher's sex X

Table 4

Correlation Matrix for Student CIS Scores, Teacher Sex,
Student Sex and an Interaction Variable

Variable	CISPOST	CISPRE	TSEX	SSEX	INTSEX
CISPOST	1.000				
CISPRE	.777*	1.000			
TSEX	-.022	.002	1.000		
SSEX	-.263*	-.280*	.028	1.000	
INTSEX	-.025	-.030	.022	.091	1.000

* $p < .05$

Table 5
Multiple Linear Regression Analysis Summary Table
With CISPOST as the Dependent Variable

Variable	Multiple R	R Square	RSQ Change	Simple R	DF	F Ratio ^a
TSEX	.022	.000	.000	-.022	-	-
SSEX	.263	.069	.069	-.263	-	-
INTSEX	.263	.069	.000	-.025	3,56	.00

^aFor sr^2

student's sex) as independent variables. The degrees of freedom are determined by using the number of teacher/student groups. For example, for teacher 1, the girl students were considered as one case, while for the same teacher, the boys were considered as another case. Therefore, thirty teachers times two groups for each teacher (one representing girls and the other boys) equals sixty teaching units for an N of 60.

The important aspect of Table 5 is that the interaction of the sex of the teacher and the sex of the students (INTSEX) did not account for a statistically significant amount of the variance of the dependent variable ($F=.00$, $p>.05$). In testing the amount of variance of the dependent variable accounted for by the interaction variable, the F ratio of the semipartial r-squared was used. The semipartial r squared (sr squared) is the unique amount of the variance of the dependent variable that is accounted for by the particular independent variable when all previous variables are entered into the regression analysis. Since the amount of variance accounted for by the interaction variable is not significant, null hypothesis one cannot be rejected.

In Table 6, the second multiple linear regression

Table 6

Multiple Linear Regression Analysis Summary Table
 With CISPOST as the Dependent Variable
 and CISPRES as a Covariate

Variable	Multiple R	R Square	RSQ Change	Simple R	DF	F Ratio ^a
CISPRES	.777	.604	.604	.777	-	-
TSEX	.777	.604	.000	-.022	-	-
SSEX	.779	.606	.002	-.263	-	-
INTSEX	.779	.606	.000	-.025	4,55	.00

^aFor sr^2

analysis summary table is given. In this particular analysis, there was one variation from the analysis indicated in Table 5, in that the presurvey scores were entered as a covariate. It can be seen that the presurvey scores accounted for approximately 60% of the variance of the posttest scores, indicating a strong relationship between pre- and postsurvey scores of the students involved. When the CIS presurvey scores are entered into the regression analysis, to control statistically for the initial S/E career interest, the interaction of the sex of the student and the sex of teacher again does not account for a statistically significant amount of the variance of the CIS postsurvey scores ($F=.00$, $p>.05$).

Results of Teacher Effectiveness Analysis

A multiple linear regression analysis was performed to test null hypotheses two through five. The analysis consisted of a hierarchical ordering of the independent variables, CIS presurvey scores, the sex of the teacher, and the teacher effectiveness variables which are: (a) classroom laboratory emphasis, (b) the level of understanding of science, and (c) the level of career

interest in being a math-science teacher, against the postsurvey scores for only the girl students.

Listed in Table 7 are the means and standard deviations for the variables included in this regression analysis. It should be noted that the .53 value for teacher sex indicates that there were slightly more female teachers involved in the analysis than male teachers (14 men, 16 women). The mean value for the lab emphasis in the classroom is approximately 10%. Therefore, on the average, students were involved in laboratory activities about 20-25 minutes per week. It should be mentioned here that the large standard deviation indicates that there is wide variation in the amount of lab time emphasized by the science teachers. It can be seen in Appendix A that 17 of the 30 science teachers were not observed as having their students do any lab work. Generally, teachers who did emphasize classroom laboratory work, had the students involved in laboratory activities 20-30 percent of the time.

It can also be seen in Table 7 that the mean TOUS score was approximately 35 points out of a possible 60 for the 30 science teachers. The mean score of .47 for the SCII indicates that slightly less than half of the science teachers involved are similar in their level of

Table 7

Means and Standard Deviations for Science Teachers
in Reference to Girls' CIS Scores and Teacher Variables

Variable	Mean	Standard Deviation
CISPOST	15.8	9.0
CISPRE	16.4	9.2
TSEX	.53	.5
LAB	9.8	14.2
TOUS	34.9	9.7
SCII	.47	.5

N of Cases = 30 Teachers, 992 Students

math-science teacher career interest to the math-science teachers used as the norm group for the SCII. The individual science teacher scores for both the TOUS and SCII are listed in Appendix A.

Table B is the correlation matrix generated by the SPSS Program in which each variable is correlated with each of the other variables. The correlation between the girls' presurvey and postsurvey scores on the CIS is .77, which is statistically significant ($p < .05$). The only other bivariate correlations that were statistically significant ($p < .05$) were the correlations between the TOUS score and teachers sex and the SCII score and the teacher's sex. These correlations, $-.43$ and $-.45$, respectively, indicate that male teachers in this study had higher scores on the TOUS and were higher in their career interest as a math-science teacher than were female teachers.

In Table 9, the multiple linear regression summary table is given for the regression of the presurvey CIS scores, the sex of the teacher and the teacher effectiveness variables against the postsurvey CIS scores for the 992 girls. The independent variables were entered into the regression analysis hierarchically with the presurvey scores entered first, followed by the

Table 8
Correlation Matrix for Girls' CIS Scores
and Teacher Variables

	CISPOST	CISPRE	TSEX	LAB	TOUS	SCII
CISPOST	1.000					
CISPRE	.771*	1.000				
TSEX	-.015	.006	1.000			
LAB	.016	.021	.299	1.000		
TOUS	-.002	-.017	-.428*	.173	1.000	
SCII	.050	.010	-.450*	.040	.335	1.000

* $r < .05$

Table 9

Multiple Linear Regression Analysis Summary Table
for Girls' CIS Scores and Teacher Variables

Variable	Multiple R	R Square	RSQ Change	Simple R	DF	F Ratio ^a
CISPRE	.771	.594	.594	.771	1,28	41.02*
TSEX	.771	.595	.000	-.016	2,27	.000
LAB	.771	.595	.000	.016	3,26	.000
TOUS	.771	.595	.000	-.002	4,26	.000
SCII	.772	.596	.001	.050	5,24	.006

^aFor sr^2

*p < .05

teacher sex, classroom lab emphasis, TOUS score and SCII coding. Since the teachers had significantly different numbers of students as indicated in Appendix A, each student was weighted individually in the regression analysis, but the testing for statistical significance was done using $N=30$.

The results included in Table 9 demonstrate that 59% of the variance of the CIS postsurvey scores was accounted for by the CIS presurvey scores, while the other 4 variables accounted for only an additional .13% of the variance. The amount of variance accounted for by the presurvey is statistically significant ($F=41.02$, $p<.05$) while the other variables are not. Because the 4 independent variables did not account for a significant portion of the variance of the CIS postsurvey scores, I was unable to reject null hypotheses two through five.

The results of Table 10 include the adjusted means for the girls' CIS postsurvey scores. These means have been adjusted for the girls' CIS presurvey scores, for each independent variable dichotomy, following the technique described by Cohen & Cohen (1975). The small observed differences between the adjusted means, for the dichotomized TSEX, LAB, TOUS, and SCII, reflect the nonsignificant F-ratios reported in Table 9.

Table 10

Mean 8th Grade Girls' CIS Postsurvey Scores
for Four Teacher Variables Which Have Been Dichotomized
and Adjusted for the CIS Presurvey Differences

Variable	Group	Category	Adjusted CISPOST Means
TSEX	Female	1	15.6
	Male	0	16.0
LAB	Uses Labs	1	15.8
	No Labs	0	15.7
TOUS	Score $\geq$ 39	1	15.7
	Score < 39	0	15.8
SCII ^a	Math-Sci Teacher	1	16.1
	Interests Similar		
	Interests Dissimilar	0	15.4

^a SCII Math-Science Teacher Scale as Compared to a Norm
Group of Satisfied and Successful Math-Science Teachers.

CHAPTER V

SUMMARY AND CONCLUSIONS

The Problem

The two main objectives of this study were to determine (a) whether the interaction of the sex of eighth grade science teachers and the sex of eighth grade students is related to the S/E career interests of eighth grade students, and (b) whether the eighth grade science teachers' sex, classroom laboratory emphasis, level of understanding of science and career interest in being a math-science teacher were related to the Science and Engineering career interests of their female eighth grade students.

The study involved 13 middle/junior high schools, 30 eighth grade science teachers and 1937 eighth grade students.

Procedures

Using the CIS, all eighth grade students involved were presurveyed by their science teachers during the

first week of September, 1981 and postsurveyed during the first week of April, 1982. At these survey times, the name of their science teacher and the sex of the student were recorded for future reference. During the months of January through April, the eighth grade science classes of participating teachers were periodically observed for the amount of laboratory activity time in which the students were involved. During the month of March, teachers completed the Test on Understanding Science and the Strong Campbell Interest Inventory.

The data were analyzed using multiple linear regression analysis to test null hypotheses one through five.

Principal Findings

The results of the statistical treatment of the data gave evidence that the variables under consideration, for null hypotheses one through five, did not account for a statistically significant amount of the S/E career interest of eighth grade students or girl students by themselves. Therefore, I was unable to reject null hypotheses one through five. For the eighth grade students in this study, these findings indicate that the

eighth grade science teachers' sex, classroom lab emphasis, level of understanding of science and career interest in being a math-science teacher did not systematically influence the students' S/E career interests.

It is important to point out that in all of the analyses, the covariate CIS presurvey scores accounted for a statistically significant amount of the variance of the CIS postsurvey scores. This indicates that the S/E career interests of the eighth grade students were relatively stable over the eight month period.

In both the CIS postsurvey and presurvey results, eighth grade boys demonstrated significantly stronger S/E career interests than those of eighth grade girls. When the CIS postsurvey scores of the eighth grade girls and boys were adjusted for the CIS presurvey scores, the differences between the girls and boys scores were not found to be significantly different. Therefore, the change in S/E career interest for both boys and girls over the eight month study period was the same.

Discussion and Conclusions

Several previous researchers have reported that the

role of science teachers in influencing girls S/E careers is very important (Button & Brown, 1980; D'Leary, 1974; Stake & Granger, 1978; Tidball, cited in "Women in Science, 1975; Trotter, 1976). In questionnaires administered to precollege science students, it has been demonstrated that students generally rated high school science teachers and junior high science teachers as being the first and second most important influences to their S/E career interest (Koelsche, 1965; Lindsay, 1973; Wright & Hounshell, 1981). The results of my study are not consistent with the findings of these researchers. My findings indicate that, over the eight month period, the science teachers did not have a significant influence on the S/E career interests of the students.

In a 1978 study by Stake and Granger, it was concluded that, when the sex of the science teacher and science student were the same, there was a greater science career commitment than when the sexes were different. They reported that there was a statistically significant interaction between student and teacher sex, with teachers acting as sex role models for their students. It should be pointed out that my results are not in agreement with Stake and Granger (1978) and this disagreement may be due to the fact that my sample

consisted of all eighth grade students, while Stake and Granger were working with high school students who had already expressed an interest in science. It has also been reported by Weiss (1977, cited in Buccino, 1980) that, in grades 7-9, only 36% of the science teachers are women. It has been hypothesized by a number of researchers that, because of this small number of women science teachers as compared to men, the low number of women entering S/E careers is due to the absence of adequate numbers of women science teachers as role models for girls (Button & Brown, 1980; Joesting & Joesting, 1972; Stake & Granger, 1978). The results of my study indicate that, for eighth grade students over an eight month period, there is no interaction between the students' sex and teachers' sex in reference to S/E career interest. It should be noted that this study occurred in an area where the numbers of men and women science teachers are about equal (Schlessinger et al., 1973).

My findings are in agreement with four previous studies which have reported (for fifth and sixth grade, junior high school, high school and college level students) that the teacher did not significantly affect the science interest or science career interests of their

students (Lindsay, 1973; Reed, 1961; Vockell & Lobonc, 1981; Weishaar et al., 1981).

It has been reported by several researchers that the S/E career interests of boys at the secondary school level are significantly higher than those of girls at the same level (Hardin & Dede, 1973; Stake & Branger, 1978; Wright & Hounshell, 1981). These conclusions are supported by my research in which I found that boys had a mean score of 21 on the CIS as compared to a mean score of 16 for girls and that this difference was statistically significant.

Lantz and West (1977), reviewed a number of National Science Foundation programs funded to increase the number of girls going into S/E careers, and recommended that a longer contact period between role models and students should be used in programs of this type. They suggested that the reason the programs did not detect significant changes in the girls' career interests was because of the short contact time in the programs, which were usually a few days to a few weeks.

In my study, the period of contact was over an eight month period, with each student having contact with the science teacher daily for 45-50 minutes. Even with this extended contact time, the teacher had little influence

in the S/E career interests of their students. In my opinion, the inability of the NSF programs to observe changes was due to the absence of a valid and reliable instrument which measures S/E career interest as well as the short contact period between girls and women scientists. In my study, I developed both a valid and reliable instrument which should have solved the problem of accurately measuring S/E career interests. I also used a contact period of almost a full school year, which should have solved the problem of insufficient contact time between students and scientists. I discovered, in talking to a number of the eighth grade science teachers, that they thought of themselves as teachers and not as practicing scientists. Since the science teachers, in my study, appear not to be as strongly oriented to science as practicing scientists would be, they may not be strong models for science and engineering careers.

Gardner (1979) has reported that there has been a general trend in science classes to decrease labwork and substitute more demonstrations and deskwork. The findings of my study are consistent with Gardner's conclusions in that, of the 30 teachers involved in the study, only 13 were observed to involve their students in any laboratory activities during the observed periods.

The most frequently observed teaching method in the eighth grade science classrooms was deskwork, which involved the students reading the textbook and then answering questions printed on a worksheet. In my study, on the average, science teachers used labwork approximately 10% of the time. The value of approximately 10% is lower than that reported by Weiss (1978) who, in a national survey, reported that students in grades 7-9 were involved in laboratory ("hands-on") work 24% of the time.

It has been suggested by several researchers that students who have more opportunity to experience laboratory work will have a greater interest in science, which in turn may influence their interest in science careers (Pella, 1961; Pennington, 1960; Shulman & Tamir, 1973; Sund & Trowbridge, 1967; Tamir, 1976). My findings do not support the conclusions of these researchers, but rather support the conclusions of several other researchers, who found that there is no difference between science interest and S/E career interests of students who have not experienced labs as compared to those who had labs (Blosser, 1981; Pella & Sherman, 1969).

Perkes (1967-68) has suggested that better science

teaching involves a balance of student and teacher centered activities. In reference to S/E career interest, these conclusions are not consistent with my findings since the percent of lab time was not significantly related to eighth grade student S/E career interest.

It should be pointed out that only one science teacher of the 30 involved was observed to spend any time on science careers in his/her classroom teaching. Hasan (1975) concluded that, if career interest is a desired end product of a science program, science career-related activities and vocational programs are necessary. If science teachers were not observed spending classtime teaching science career education, it may mean that they do not feel that science career education is an important objective of their science teaching.

The science teacher's level of understanding of science as measured by the TOUS was not found to be related to the S/E career interests of their students. It is interesting to note that the mean score for these eighth grade science teachers on the TOUS, which was approximately 35, was significantly lower than means reported in previous studies. The TOUS group means ranged from 40.5 for an elementary science survey class

at the college sophomore level, to 51, for practicing scientists (Miller, 1963; Schmidt, 1967-68; Schmidt & Yager, 1966-67, cited in Schmidt, 1967-68). All of these means were reported from studies done in the 1960's, so they may not seem applicable to the present study. However, in a recent testing of 36 secondary school science teachers in a summer institute at Florida Institute of Technology during 1981, I calculated a mean TOUS of 43. The 30 science teachers involved in my study seem to have a lower understanding of science as measured by the TOUS than that of other reported groups. What implications this has in reference to their teaching effectiveness or ability to promote S/E careers is unclear at this time.

It was also discovered in this study that male science teachers had a significantly greater understanding of science as measured by the TOUS than the female science teachers. These findings have not been reported in other studies, so their implications are also unclear. This difference may be due to the fact that the men had, on the average, been teaching science longer than the women, and many of the women expressed a lack of confidence in their ability to communicate science to their students.

It may be concluded from the results of this study that the level of a science teacher's career interest in being a math-science teacher is unrelated to the S/E career interest of his/her students. This is somewhat contrary to other studies which suggest that teacher interest in teaching is an important factor in inspiring interest in their students (Brophy & Good, 1974; Bybee, 1973; Dieter & Hounshell, 1975; Stedman & Breen, 1977). Since these studies do not relate directly to career interest of the student but only interest in the subject, the results of my study and the results of other research may not be comparable. It is surprising to me that less than half of the science teachers involved in my study had interests that were similar to the occupational scale norm group, which consisted of satisfied and successful math-science teachers. It was also discovered that the male teachers involved in this study had significantly higher interest in their chosen career than the female teachers. What the implications of these results are for the general objectives of a science curriculum is unclear at this time.

In my study, it was discovered that the S/E career interests of the eighth grade students was quite stable over the eight month period of the study. This is in

agreement with other studies involving secondary school students which reported similar findings of only a 21%-30% change in career interest from 9th to 12th grade (Hansen & Stocco, 1980; Wynn, 1963). These results may indicate that S/E career interests of students are formed earlier than 8th grade and that future studies should investigate when student S/E career interests are formed.

In conclusion, there must be other more important factors that are involved in influencing girls' S/E career interests than those measured in this study. These results suggest that the influence of the sex and teaching effectiveness of one science teacher over one school year is indeed very small, as compared to all of the other school and societal influences which a girl will face before she finally decides upon a career.

Recommendations for Future Research

It has been suggested by Lantz and West (1977) that programs and studies involved in factors influencing women S/E career interests should deal only with those students who are already interested in S/E careers. It might be of value to look at the science teacher influence on the S/E interests of those students already

interested. Since in my study, the S/E career interests of the girls were relatively stable over the entire school year, the results suggest that a long term study is needed to get a better idea of when S/E career interests of girls are actually established and what are the major influences. This, of course, would require a study which would follow a group of students through their school years until they finally become employed.

The career interests of a large number of the science teachers in this study were not similar to the interests of satisfied and successful math-science teachers of the SCII norm group. It might be of value to find out why so many of these teachers have interests that are dissimilar to those in the SCII norm group. It might be of further value to look at the S/E interests of the science teachers and see if it is related to their students' S/E interests. Since the science teacher may not be as effective a role model for S/E careers as practicing scientists and engineers, a study of how best to train science teachers to be better role models for S/E careers may be necessary.

This study indicates that when teachers do what they normally do in the science classroom, they do not influence the S/E career interests of the girls or boys

in their classes. An experimental study, that included both male and female teachers and students, in which a weekly S/E career education program was incorporated into the experimental classes and no program into the control classes, might help to demonstrate whether science teachers could be a significant influence in students' S/E career interests.

Since the teacher traits utilized in this study were found to be unrelated to S/E career interests, a factor analysis of all the possible factors that may be an influence might be more helpful in pinpointing what factors or groups of factors are the most important. Listed in Chapter II are the major career barriers for women in S/E. These barriers would probably be a good starting point in the selection of variables, for a factor analytic study.

Vockell and Lobonc (1981) have suggested that girls' and boys' degrees of interest are similar for the biological sciences but are different in the physical sciences and engineering areas. This suggests that student career interest in the physical sciences and engineering, and the biological sciences may need to be investigated separately.

It was somewhat disappointing to discover that the

science teachers involved in my study were not found to have a significant influence on the S/E career interests of their eighth grade students.

In the 1981 Project Synthesis Report for Science Education, Dr. Norris Harms has stated that:

The primary teacher characteristics associated with career-choice goal are awareness of the importance of educational and career planning for students' futures and a sense of responsibility for input into career-related decisions. A teacher with these attitudes will naturally keep abreast of the science-related job market, be aware of sources of career information and community resources, and pass this information on to students as a natural and normal part of science classes. The aware teacher will find many opportunities to discuss specific careers associated with specific topics in science and science-related societal issues. (Harms & Yager, 1981, p.124)

The above statement by Harms, in light of my study, suggests that it might be time for science teachers to reevaluate the objectives of their science programs and determine if they are meeting the science and engineering career needs of their students.

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APPENDIX A

CIS PRESURVEY AND POSTSURVEY MEANS FOR
GIRLS AND BOYS OF EACH TEACHER, INCLUDING
NUMBER OF STUDENTS, PLUS DATA ON TEACHER
EFFECTIVENESS VARIABLES AND TEACHER SEX

**CIS Presurvey and Postsurvey Means for Girls and Boys of Each Teacher,
Including Number of Students, Plus Data on Teacher Effectiveness Variables and Teacher Sex**

Teacher	Girls			Boys			SEX	LAB	TOUS	SCII
	Mean CISPRE	Mean CISPOST	N	Mean CISPRE	Mean CISPOST	N				
1	13.67	13.70	33	17.84	17.53	32	M	00	35	1
2	13.40	6.40	5	17.14	14.55	22	F	00	17	1
3	20.25	17.25	4	15.00	19.50	6	M	00	30	0
4	16.22	16.61	51	23.59	23.41	34	F	37	34	1
5	14.38	14.50	8	20.50	19.25	8	M	00	44	0
6	12.59	12.13	39	19.73	19.93	44	M	00	39	0
7	19.91	19.55	56	23.68	23.76	50	M	00	39	1
8	15.48	13.67	21	23.45	21.17	29	N	21	39	0
9	15.24	15.48	42	20.43	19.74	47	M	25	42	1
10	16.22	16.10	72	23.30	22.41	46	F	22	35	1
11	15.73	15.60	15	20.08	19.17	12	M	00	39	0
12	15.44	15.06	50	21.78	20.27	51	F	21	41	1
13	14.18	15.09	11	21.25	19.67	12	F	03	49	0
14	15.42	14.80	59	24.06	23.32	47	M	20	46	1
15	17.53	19.20	15	18.85	16.35	20	M	00	39	1
16	15.50	14.19	16	20.38	18.50	24	F	00	44	1
17	17.43	15.78	49	21.09	18.69	45	F	50	38	0
18	15.75	14.70	40	24.06	22.29	31	F	00	25	0
19	16.61	15.06	18	26.18	23.55	11	F	27	32	0
20	14.21	12.57	14	20.92	19.58	12	M	00	36	1
21	19.12	18.71	34	23.22	20.52	27	F	00	27	0
22	11.33	4.67	6	16.43	13.57	7	F	00	11	0
23	17.56	16.59	54	22.47	21.53	74	M	27	44	1
24	18.06	17.08	64	20.60	20.49	45	F	04	36	0
25	18.60	21.90	10	23.73	23.82	11	M	00	26	1
26	16.00	17.86	7	17.64	18.73	22	F	00	07	0
27	14.90	13.83	42	21.90	18.79	39	F	06	40	0
28	12.61	10.61	18	18.23	16.33	30	F	00	40	0
29	17.88	16.82	67	22.41	20.12	51	M	00	39	1
30	17.97	16.76	72	25.84	25.79	56	F	32	35	0

KEY

N - Number of Students

SEX - M = Male, F = Female

LAB - Percent of Classroom Lab Emphasis

TOUS - Score on Test on Understanding Science, based on 60 questions

SCII - Strong Campbell Interest Inventory score on Math-Science Occupational scale,
1 = similar to norm group, 0 = not similar to norm group

APPENDIX B
CAREER INTEREST SURVEY
FORM B

CIS
"CAREER INTEREST SURVEY"
FORM B

This survey was developed in the course of research at the Science Education Department, Florida Institute of Technology, Melbourne, Florida by Edward F. Donovan July 29, 1981.

CAREER INTEREST SURVEY - GENERAL INSTRUCTIONS

This is a career interest survey to help you decide about jobs that you would like or not like to do. As you choose your answer to each question, try to be frank and truthful. Remember that the results will be used to measure your interest in careers and that there is no "right" or "wrong" answer.

The interest survey contains 36 questions and is divided into four parts. Part I contains 30 activity groups which must be answered using one of three possible choices. Part II contains 20 job groups in which you must choose one of the 3 possible jobs listed. Part III contains five questions with each question containing five possible choices. Part IV contains one question for which you must state your possible future occupational choice.

After you choose the answer that best describes your interest, you should mark the proper space on the answer sheet with the special pencil you have been given. Make the mark as long as the rectangle. Move the pencil point back and forth firmly to make a heavy black line within the boundaries of the rectangle. If you change your mind about an answer, erase your first mark completely. Mark only one answer for each question.

Example: 100. Which activity would you like to do the most?
a. study cancer b. write books. c. build airplanes.

100 ☒ a ☐ b ☐ c

Notice that in the above example the student selected choice b and indicated this by filling in the rectangle marked b on the answer sheet. Be sure that you mark only one answer for each question on the separate answer sheet. Also make sure you read the specific directions for each part.

You should make sure that you answer every question. Work carefully, but do not spend too much time on any one question. If you finish before time is called turn your answer sheet and interest survey booklet over and sit quietly until the rest of the students are finished. There is no time limit for finishing this survey, but it should take you about 30 minutes to complete.

Please do not mark this booklet in any way.

DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO.

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PART I - OCCUPATIONAL ACTIVITIES

This part contains 30 questions numbered 1-30. Each question has a group of 3 activities. You are to decide which activity of the 3 in the group you would like to do the most. Then indicate this choice by filling in the correct letter in the rectangle on the answer sheet next to the correct group number.

Example: 101. Which activity would you like to do the most?
 a. Collect butterflies.
 b. Build homes.
 c. Fly airplanes.

If you selected b as your choice you would fill in rectangle b on your answer sheet next to number 101.

Which activity would you like to do the most?

1. a. Defend people in a court of law.
 b. Operate a dog kennel.
 c. Perform surgery in a hospital.
2. a. Put out fires in homes and buildings.
 b. Develop plans and supervise building of bridges, tunnels, etc.
 c. Interview people for television newsprograms.
3. a. Study how diseases spread in cities.
 b. Sell homeowner's insurance.
 c. Take pictures of weddings and other social events.
4. a. Purchase equipment and supplies for businesses.
 b. Teach students how to play musical instruments.
 c. Create in a laboratory, a new synthetic cloth.
5. a. Plan and maintain gardens for other people.
 b. Design and develop new mechanical equipment for industry.
 c. Create new types and styles of clothing.
6. a. Act in movies and television programs.
 b. Write articles for magazines and newspapers.
 c. Develop new types of plants in a greenhouse.
7. a. Be the owner of a large fast-food restaurant chain.
 b. Develop nature trails for national parks.
 c. Prepare accurate plans for machine equipment.
8. a. Operate a telephone switchboard.
 b. Restore antique furniture.
 c. Design special programs to treat disabled and crippled people.
9. a. Drive a school bus.
 b. Operate farm machinery.
 c. Study rocks and fossils.

GO ON

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2

Which activity would you like to do the most?

10.
 - a. Find cures for human diseases.
 - b. Draw road maps for transportation planners.
 - c. Investigate crimes and arrest criminals.
11.
 - a. Cut and style people's hair.
 - b. Collect and identify insects.
 - c. Repair televisions and radios.
12.
 - a. Interview and hire employees for a company.
 - b. Create advertisements for radio and television.
 - c. Design systems to clean polluted water and air.
13.
 - a. Study living things under a microscope.
 - b. Build and remodel houses.
 - c. Operate machines in a machine shop.
14.
 - a. Build houses from blueprints.
 - b. Maintain financial records for a business.
 - c. Study planets, comets, stars, etc.
15.
 - a. Sell real-estate.
 - b. Operate your own business.
 - c. Study how the human brain works.
16.
 - a. Make reservations for people taking vacation trips.
 - b. Develop plans for construction of airports, hospitals, etc.
 - c. Teach pre-school children arts and crafts.
17.
 - a. Study plant life in a forest.
 - b. Teach students how to paint pictures.
 - c. Write children's storybooks.
18.
 - a. Operate heavy construction equipment.
 - b. Draw diagrams and pictures for books.
 - c. Study the chemical properties of metals.
19.
 - a. Study how the human body fights disease.
 - b. Sell small appliances in a department store.
 - c. Teach people how to sell insurance.
20.
 - a. Design an electric powered car.
 - b. Operate office machinery.
 - c. Inspect public buildings for fire hazards.
21.
 - a. Write short stories and novels.
 - b. Discover new sources of fossil fuels for energy.
 - c. Supervise research activities of school education programs.
22.
 - a. Advise people on income tax preparation.
 - b. Study how chemicals in food affect people.
 - c. Treat patients and take medical histories for doctors.
23.
 - a. Work in a bank cashing payroll checks.
 - b. Design electronic circuits for radios and televisions.
 - c. Grow vegetables for supermarkets.

GO ON

Which activity would you like to do the most?

24.
 - a. Prepare meat and poultry for sale in supermarkets.
 - b. Study how air and water pollution affect people.
 - c. Deliver, collect and sort mail.
25.
 - a. Perform office duties such as typing and filing.
 - b. Study how to control insect pests on crops.
 - c. Sell sporting equipment and supplies.
26.
 - a. Examine eyes for vision problems.
 - b. Direct a local orchestra.
 - c. Prepare policies and budgets for a school.
27.
 - a. Study earthquakes and volcanoes.
 - b. Play a musical instrument in an orchestra.
 - c. Repair automobile engines.
28.
 - a. Mine ore, rock or coal from the earth.
 - b. Direct recreational activities at summer camps.
 - c. Treat and prevent tooth decay in people.
29.
 - a. Teach high school foreign languages.
 - b. Teach high school science.
 - c. Teach high school history.
30.
 - a. Study about endangered animals and plants.
 - b. Repair damaged cars and trucks.
 - c. Supervise religious education for a parish or church.

GO ON

PART II - OCCUPATIONS

This part contains 20 groups each having 3 jobs numbered 31-50. You are to decide which job for each group of 3 you would like to do the most. Then indicate this choice by filling in the correct letter in the rectangle on the answer sheet, next to the correct group number.

Example: Which occupation would you like to do the most?

102. a. doctor b. plumber c. actor/actress

If you selected c as your answer you would fill in rectangle c on the answer sheet next to number 102.

Which job would you like to do the most?

- | | | |
|--|-----------------------------------|-----------------------------------|
| 31. a. building inspector | b. biological oceanographer | c. air traffic controller |
| 32. a. production manager | b. electrical engineer | c. writer |
| 33. a. bookkeeper | b. psychologist | c. chef/cook |
| 34. a. beautician | b. mail carrier | c. registered nurse |
| 35. a. electrical engineer | b. commercial artist | c. accountant |
| 36. a. office worker | b. airplane pilot | c. zoologist |
| 37. a. computer specialist | b. telephone operator | c. school counselor |
| 38. a. pharmacist | b. interior designer | c. electrician |
| 39. a. flight attendant | b. agricultural specialist | c. stenographer |
| 40. a. librarian | b. security guard | c. veterinarian |
| 41. a. computer engineer | b. hotel manager | c. bank officer |
| 42. a. environmental scientist | b. airplane mechanic | c. computer operator |
| 43. a. diplomat | b. musician | c. physicist |
| 44. a. photographer | b. aerospace engineer | c. social worker |
| 45. a. receptionist | b. surveyor | c. chemist |
| 46. a. junior high
industrial arts
teacher | b. junior high
english teacher | c. junior high
science teacher |

GO ON

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5

Which job would you like to do the most?

- | | | |
|----------------------------------|--------------------------|------------------------------|
| 47. a. sheet metal worker | b. human biologist | c. newspaper reporter |
| 48. a. medical technologist | b. welder | c. jeweler |
| 49. a. lawyer | b. meteorologist | c. real-estate salesperson |
| 50. a. college science professor | b. college art professor | c. college history professor |

GO ON

PART III - PRESENT AND FUTURE

This part contains five questions. Each question contains five choices. Choose the answer that best describes your interest and indicate your answer on the answer sheet next to the correct question number.

31. Which one of the choices below best describes the high school program you are interested in taking?
- General program - meeting basic requirements for graduation, with no emphasis on any special preparation.
 - Commercial or business - preparing for an office related job such as a clerk, secretary, bookkeeper, etc.
 - College preparatory - program to enable you to enter a college degree program.
 - Vocational program - preparation for a trade school for a job as a mechanic, factory worker, carpenter, etc.
 - Other (not stated above).
32. How much schooling do you plan to complete in your life?
- Less than a high school diploma.
 - Complete high school with a diploma.
 - Complete a vocational, business or technical training at a trade-centered community college.
 - Complete a two-year college program.
 - Complete a four-year college program or more.
33. Of the school subjects listed below, which one do you like the best?
- Social Studies
 - Mathematics
 - English
 - Science
 - Foreign Language
34. Select the job group below that you feel best describes your future job interest.
- Mechanical, Industrial, Construction (repairer, mechanic, electrician, factory worker, carpenter, bricklayer, etc.).
 - Business, Clerical, Sales (accountant, stockbroker, typist, bookkeeper, office worker, insurance agent, salesclerk, etc.).
 - Artistic (art, drama, music, TV, radio, writing, etc.).
 - Social Service (clergy, social worker, teacher other than science, counselor, lawyer, etc.).
 - Other (job group not listed here).
35. Select the job group that you feel best describes your future job interest.
- General labor (barber, butcher, domestic worker, general laborer, road crew worker, etc.).
 - Scientific, Engineering, Medicine (biologist, engineer, doctor, registered nurse, chemist, psychologist, science teacher or professor, etc.).
 - Agricultural (farming, ranching, logging, landscaping, etc.).
 - Public, Community Service (mail carrier, police officer, taxi driver, firefighter, etc.).
 - Other (job group not listed here).

GO ON

PART IV - YOUR OCCUPATIONAL INTEREST

36. On your answer sheet on the blue line, underneath the words "date" and "hour" write the actual job you would like to have when you finish your schooling. If you are not sure put your best guess.

STOP

APPENDIX C
ANSWER KEY FOR CIS

ANSWER KEY FOR CIS

1. c
2. b
3. a
4. c
5. b
6. c
7. b
8. c
9. c
10. a
11. b
12. c
13. a
14. c
15. c
16. b
17. a
18. c
19. a
20. a
21. b
22. b
23. b
24. b
25. b
26. a
27. a
28. a

29. b
30. a
31. b
32. b
33. b
34. c
35. a
36. c
37. a
38. a
39. b
40. c
41. a
42. a
43. c
44. b
45. c
46. c
47. b
48. a
49. b
50. a
51. c
52. e
53. d
54. e
55. b

56. Any S/E
Occupation Requiring
4 Year College Degree

APPENDIX D
MANUAL FOR THE CAREER INTEREST SURVEY
DIRECTIONS FOR ADMINISTERING CIS

REVISED March 23, 1982

MANUAL FOR THE "CAREER INTEREST SURVEY"

DIRECTIONS FOR ADMINISTERING CIS

In order to have confidence in the comparability of survey results, it is important to follow precisely the procedure outlined below. This includes reading aloud the directions on the back cover of the survey booklet. The purpose of the "Career Interest Survey" is to measure the science and engineering career interests of 7th, 8th & 9th grade students.

ASSEMBLING MATERIALS BEFORE TESTING

The following should be used as a checklist by the examiner in determining that all necessary materials are available several days before any students are to be surveyed:

1. The same number of CIS booklets as the number of students to be surveyed—plus a few extra copies for emergencies.
2. The same number of answer sheets as the number of students to be surveyed—plus a few extras for emergencies.
3. A copy of this MANUAL.
4. Pencils. (Students should not use ink.) Number 2 pencils, well sharpened, enough for all students to be surveyed, or a small supply if pupils are asked to use their own.
5. A timer—any watch or clock, or an automatic timer such as those used in the kitchen or for photography work.

ARRANGEMENTS TO BE MADE BEFORE THE SURVEY

As with materials, the examiner should consider the following a checklist. He or she should be sure that all details have been taken care of before any students are surveyed.

1. Study of survey materials. It will pay the examiner in terms of smooth survey administration to study carefully the survey booklet to be given to students, the answer sheet, and all of the directions given in this MANUAL before giving the survey.
2. Time scheduling. It should take approximately 30 minutes for students to complete the CIS. Students in a single class can be surveyed in one session of approximately 30-40 minutes. Examiners dealing with large groups may need to allow more time for distributing materials, having students fill in

information on answer sheets, and for answering students' questions.

4. Room scheduling. If possible, surveying should be conducted in a room that does not crowd examinees. Good lighting and ventilation and freedom from noise and interruption are other factors to be considered in selecting a surveying place.

5. Seat and desk arrangements. Students should be provided with reasonably comfortable seats and smooth, hard writing surfaces. Writing surfaces should be large enough to accommodate a folded survey booklet and an answer sheet.

6. Information on students. The answer sheet provides space for each student to write in name, student number, subject, teacher, date and hour. The examiner will want some additional information about students surveyed: e.g., sex, grade, and school attended.

AT THE TIME OF, AND DURING, THE SURVEYING SESSION

1. Read directions to students carefully word for word.
2. In answering questions raised by students, it is essential that the examiner

stay within the meaning and, as far as possible, the exact wording of the directions. Directions concerning guessing are particularly troublesome. Questions on this point should invariably be answered by reading these sentences from the directions: "You will make your best score by answering every question. You should work carefully, but do not spend too much time on any one item. If you finish before time is called, go back and spend more time on the questions about which you were doubtful."

NOTE: Instructions which are to be read aloud to students are underlined and double spaced. Instructions printed in single space, without underlining, are intended only for the examiner.

When the students are assembled in the examination room and seated, SAY:

The surveying period has begun. There should be no talking until you have been dismissed.

We shall now pass out survey materials. Do not open your booklet or turn it over until you are told to do so.

Distribute booklets, answer sheets, and pencils (if they are to be supplied). Then SAY:

Do not open your survey booklet until I call you to. Take your answer sheet and turn it so that you can PRINT your name on it. Put your last name first and then your first name. Fill in today's date where it says DATE. (Examiner should give the correct date.) On the next line where it says SUBJECT, print in the name of your school, and print the last name of your science teacher.

See if there are any questions. If there are no questions, SAY:

Where it says NAME, put your name and also indicate your sex, use M for male or F for female.

Notice if there are any questions. Repeat the directions if necessary. Be sure the students have filled in the correct information. Now SAY: Fill in the School /Teacher I.D. as given by your teacher on the front and back of your answer sheet. Write in the number in the boxes and fill in the rectangles. Are there any

questions before we continue?

Please to be sure there are no questions about the information to be filled in on the answer sheets.

The survey is to be machine scored, therefore SAY:

You MUST use a pencil in marking your answers, otherwise your survey paper will not score properly.

Please turn your survey booklet to DIRECTIONS, on the back cover. Read these directions silently while I read them aloud.

Read the directions from a copy of the survey booklet.

After you finish reading the directions, SAY:

Are there any questions?

Be sure that every student understands the general Directions. Emphasize any points that need emphasis and answer any legitimate questions concerning procedures. If there are questions on whether or not to guess, read verbatim the sentences that cover the point in the Directions. Then SAY:

There are 36 questions on this survey and it should take about 30 minutes to complete.

Are there any questions? I cannot answer questions after you begin working on the survey.

After answering questions, SAY:

Open your survey booklet to page 1 and begin working. Keep working until I call you to stop. If you finish before time is called, go back over the survey and check your answers. Be sure that you mark your answers in the proper spaces on the answer sheet. Make only one mark for each question.

Write on the board the exact time when students begin working on the survey. Also write on the board the approximate time when students should be finished. After 30 minutes, or when all students have finished, SAY:

STOP: Put down your pencils. I will now collect the survey materials.

Collect the answer sheets, then the survey booklets and pencils.

INSTRUCTIONS FOR RETURN OF ANSWER SHEETS

Survey Booklets: As soon as possible after surveying is finished, the survey booklets should be checked to see if students have written in them. Booklets that have been written in should have the writing erased or the booklet should be thrown out. Teachers should save the survey booklets for use again in the March/April retest. Store the survey booklets in the manilla envelope supplied.

Answer Sheets: After all surveying is finished, all completed and left over answer sheets should be given to your Science Department Head. Science Department Heads should place all answer sheets in the original manilla envelope. The answer sheets then should be sent using the Brevard County Schools Courier Service to Mr. Edward F. Donovan in care of Stone Middle School, University Blvd., Melbourne, FL 32901.

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APPENDIX E

TEACHING EVALUATION: VARIETY OF TEACHING METHODS FORM

TEACHER: _____ DATE: _____
 SCHOOL: _____ TIME: _____
 # OF STUDENTS IN CLASS: _____ CLASS PERIOD: _____
 LESSON SUBJECT: _____

TEACHING EVALUATION: VARIETY OF TEACHING METHODS

USE: Whenever the class is involved in curriculum-related activities.

PURPOSE: To see if teacher uses a variety of methods in teaching the curriculum.

DIRECTIONS: Each time the teacher changes activities, code the time & type of activity.

BEHAVIOR CATEGORIES

A. OBJECTIVES	START TIME	CODES		ELAPSED TIME
		A	B	
What is the teacher doing?				
1. Introduce new material	1.			
2. Review old material	2.			
3. Give or review test	3.			
4. Preview or directions for next assignment	4.			
5. Checking seatwork in progress	5.			
6. Other (specify)	6.			
	7.			
	8.			
B. METHODS	9.			
What methods are used to accomplish the objectives?	10.			
1. Demonstration or diagram at blackboard	11.			
2. Lecture	12.			
3. Prepared handouts (diagrams or teaching aids)	13.			
4. Media (filmstrip, slides, tape, record, etc.)	14.			
5. Questioning students to check understanding	15.			
6. Inviting and responding to student questions	16.			
7. Focused discussion (prepared, sequenced questions)	17.			
8. Unfocused discussion (rambling, no specific objective)	18.			
9. Students take turns reading or reciting	19.			
10. Drill (flashcards, definitions, chorus questions)	20.			
11. Laboratory experiment or exercise	21.			
12. Seatwork or homework assignment	22.			
13. Field trip, visit	23.			
14. Game, contest	24.			
15. Other (specify)	25.			
	26.			
	27.			
	28.			
	29.			
	30.			
	31.			
	32.			
	33.			
	34.			
	35.			
	36.			
	37.			
	38.			
	39.			
	40.			

NOTES:

APPENDIX F
LETTER OF PERMISSION TO USE THE
VARIETY OF TEACHING METHODS FORM

MICHIGAN STATE UNIVERSITY

INSTITUTE FOR RESEARCH ON TEACHING
COLLEGE OF EDUCATION - BRICKEN MALL

EAST LANSING - MICHIGAN 48824

January 18, 1982

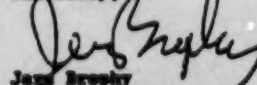
Edward P. Donovan
Graduate Research Assistant
Science Education Department
Florida Institute of Technology
Melbourne, FL 32901

Dear Mr. Donovan:

The forms that Tom Good and I included in Looking in Classrooms were explicitly intended for use by others, either as is or in modified form, so of course you have permission to use it for your dissertation research. This includes not only the modification you sent me with your letter of January 13, 1982, but any additional modification you may choose to make. Feel free to use or adapt any of the forms included in the book.

Good luck with your research.

Sincerely,



Jay P. Murphy
Co-Director, Institute for
Research on Teaching, and
Professor of Teacher Education
and of Counseling, Educational
Psychology, and Special Education

JB:js

APPENDIX G

LETTER OF PERMISSION TO USE TOUS IN RESEARCH



University of Pittsburgh

LEARNING RESEARCH AND DEVELOPMENT CENTER

14 April 1981

Mr. Edward Donovan
Science Education Center
Florida Institute of Technology
Melbourne, FL 32901

Dear Mr. Donovan:

Enclosed please find copies of TOUS forms Jv and Kv that you requested in our telephone conversation of 10 April.

I shall be glad to give permission to reproduce additional copies of TOUS, for use in your research, with the understanding that you will send me a copy of the data from the test administrations to be used for further improvement of TOUS.

Sincerely yours,

A handwritten signature in dark ink, appearing to read "LE Klopfer".

Leopold E. Klopfer
Professor of Education

slv

Enclosures

LRDC BLDG., 3636 O'HARA ST., PITTSBURGH, PA. 15260

APPENDIX H

LETTER OF PERMISSION TO PURSUE RESEARCH STUDY FROM
DIRECTOR OF SECONDARY PROGRAMS AND ASSESSMENT

BOARD MEMBERS

Frank Burkett, Chairman
Sandra M. Gelford, Vice Chairman
Robert A. Anderson
Bill Baker
Lynn Dornier

SUPERINTENDENT

Robert L. Blumhugh

School Board of Brevard County

DIVISION OF INSTRUCTIONAL SERVICES
1274 South Florida Avenue, Rockledge, Florida 32955
(305) 631-1911

July 28, 1981

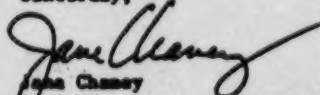
Mr. Ed Donovan
Science Education Department
Florida Institute of Technology
Melbourne, FL 32901

Dear Ed:

As I indicated in our telephone conversation, I did discuss with the area superintendents your proposed project regarding career aspirations of middle/junior high school students and your request for our middle/junior high schools to participate in the study. They indicated that your request was acceptable to them provided that the individual school principal approved of his or her school participating in the study.

If we can be of any further assistance, please don't hesitate to contact me.

Sincerely,



Jane Chaney
Director
Secondary Programs and Assessment

JC/e:b

CC: Area Superintendents
Dave Murray